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HE WORLDWIDE TECHNOLOGY WEEKLY

JULY 1, 1985

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THE PELL-MELL RUSH INTO EXPERT SYSTEMS

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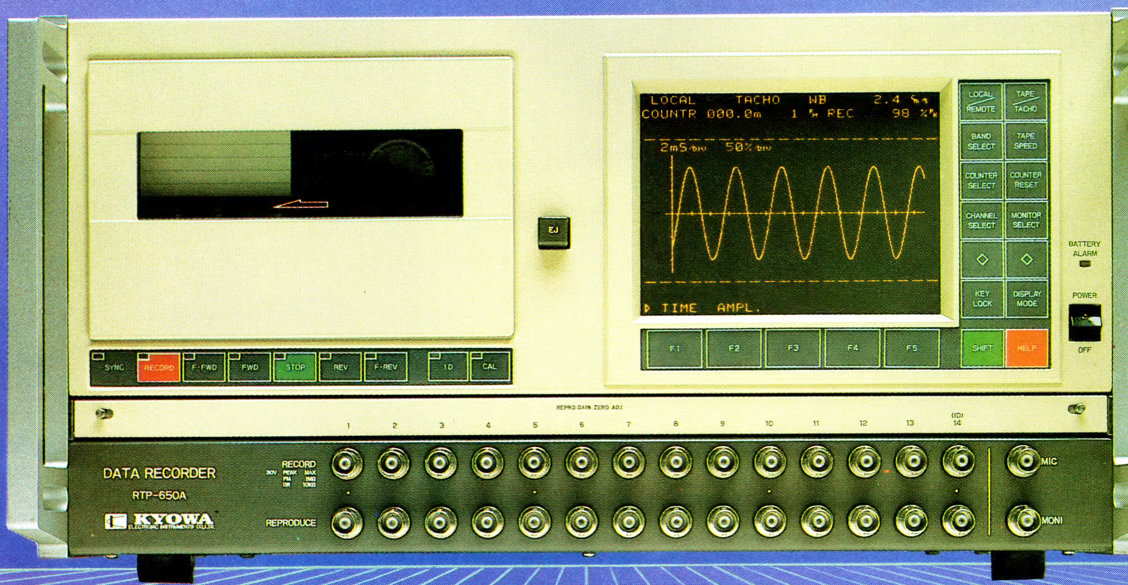

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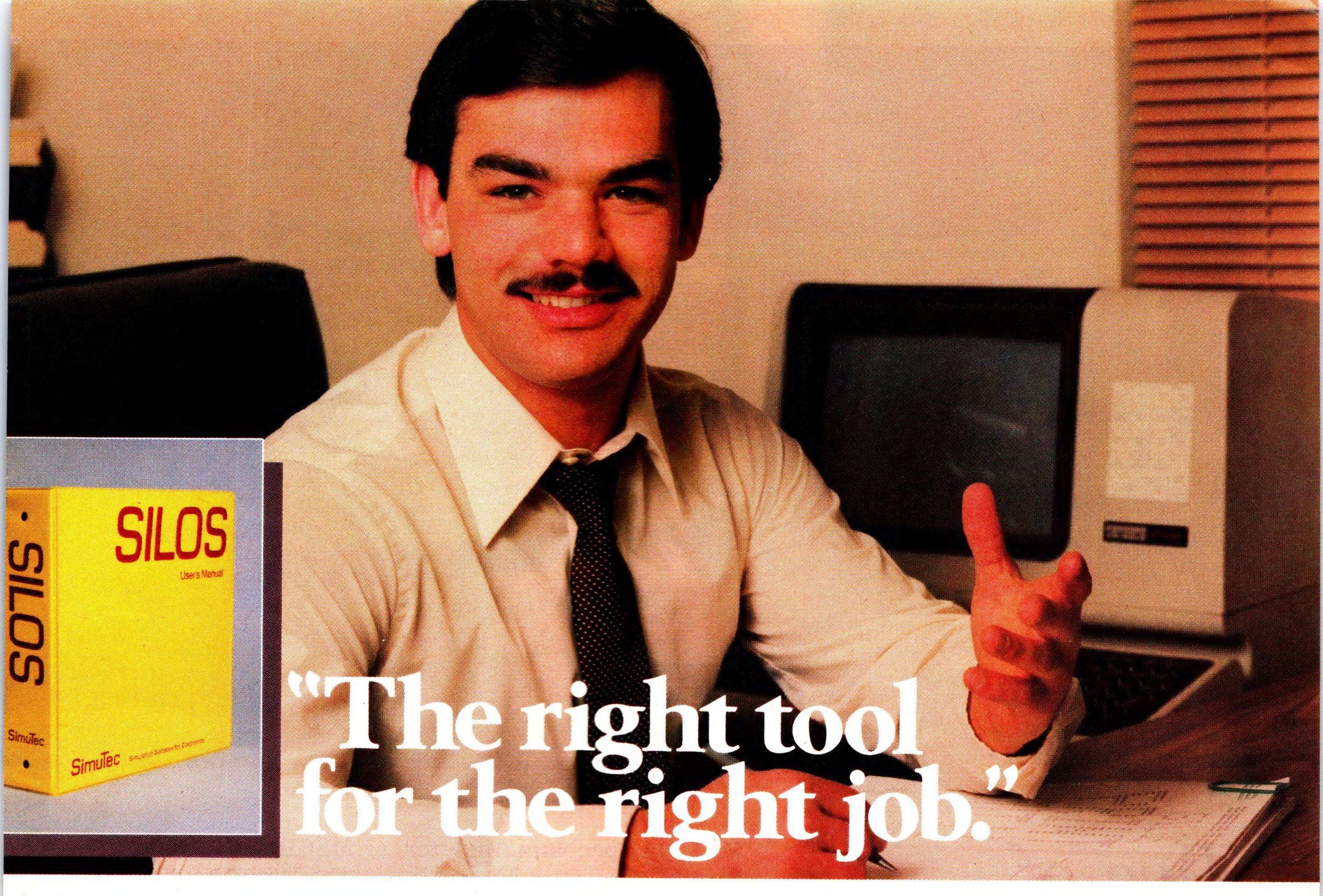

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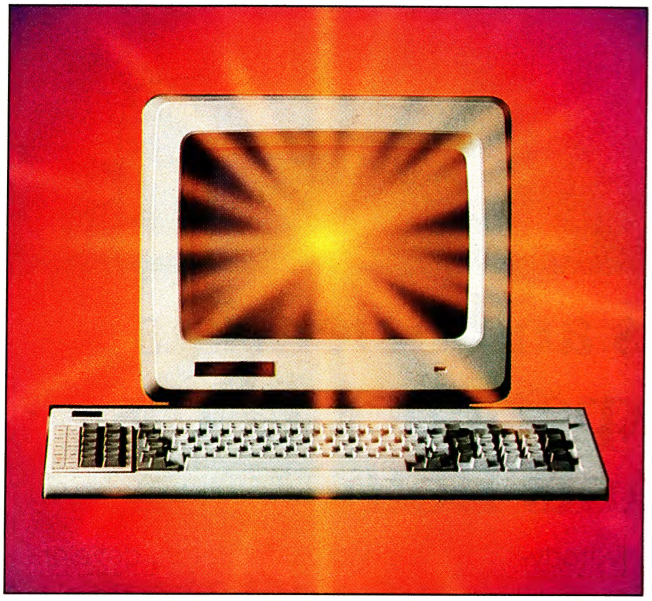

Special Report: the rush into expert systems, 54
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Cover photograph by Paul Aresu

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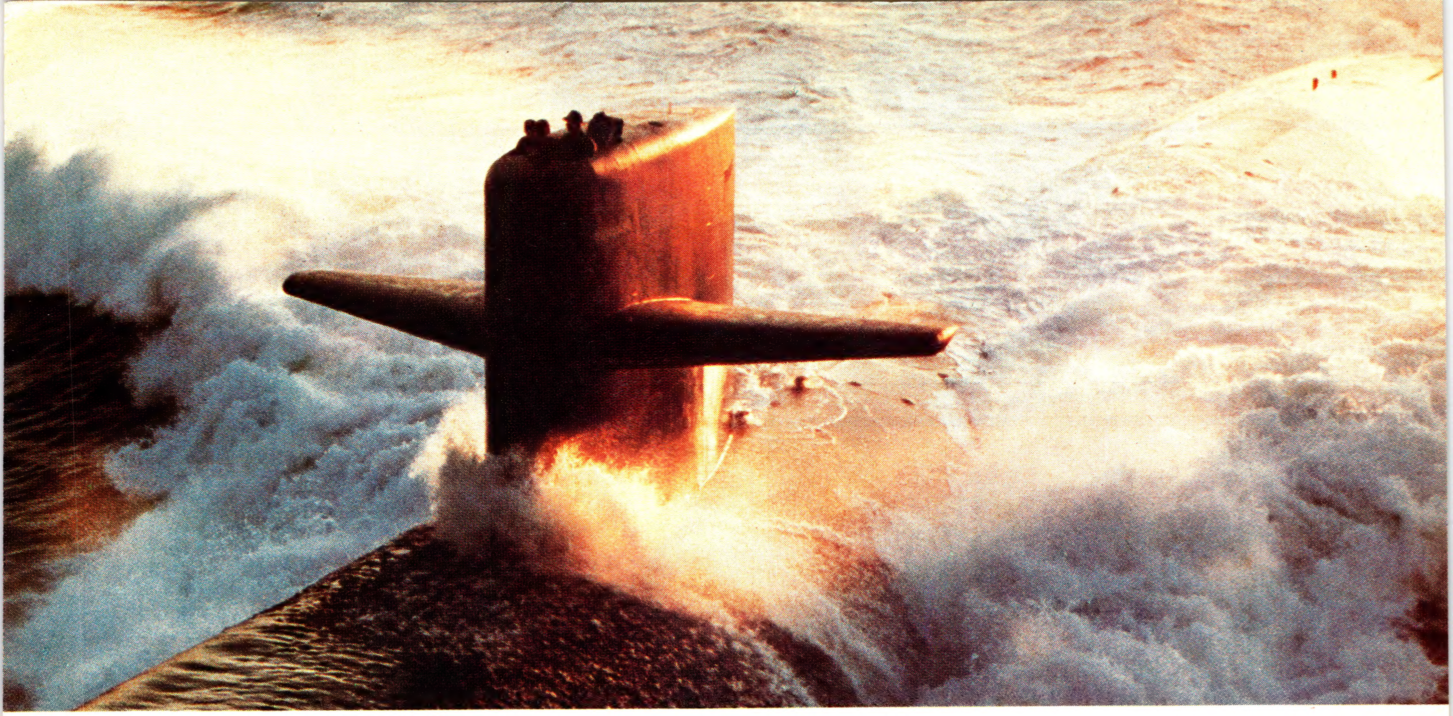

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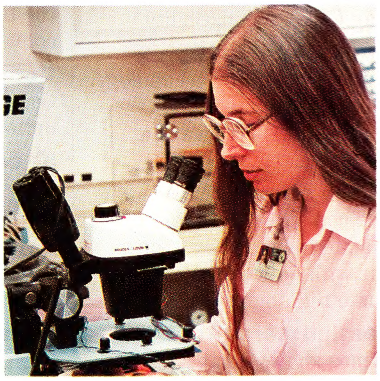

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PUBLISHER'S LETTER

I want to call your attention to a new section of the magazine called *Technology to Watch.* Under this heading, each week we will bring you timely, in-depth reporting on what our editors deem to be the most important and innovative developments in technology, wherever they may come to light.

The subjects of these articles will range from new devices and processes to complete hardware and software systems. They may involve an important new product or significant research and development. In all cases, our editors are primed to give enough details and analysis so that busy technical managers can assess the development's impact and understand how it works and why it's important.

This week's entry is a good example, and it demonstrates how fast we turn around these stories. Late in May, News Editor Jesse Leaf visited Clarity Ltd. in Israel and heard of its plans to announce a new VLSI design tool set in the U.S. in early July. He brought back details that persuaded our technical editors of the significance of Clarity's achievement. Senior Editor Jeremy Young set up an interview with Clarity's principals on their visit to New York only a week before the issue closed. The result is the exclusive story on p. 60.

We sent editorial assistant Ann Jacobs over to the PC Expo at the New York Coliseum and, in addition to the New Products roundup on p. 63, she provided this background:

PC Expo didn't fill all the space the New York Coliseum has to offer, but there was a family feeling of "y'all come" that made roaming the aisles, with their ill-fitting carpets, a pleasure. Hard sell was there, all right, but plenty of exhibitors and visitors just seemed to be hanging out. Perhaps because this show was more focused than some others, everyone's interest in the products was sharpened—everyone there was a potential customer.

The booths ran the gamut from AT&T's power tower—black on black and planted aggressively at the head of the escalator to the main exhibit floor—to Tallgrass Technology's South Seas hideaway, approached over a bridge, which carried out the jungle motif amid potted dracaenas, bamboo furniture, and a couple of stuffed hornbills. Other exhibits sank their roots in the Bauhaus or Alexander Calder.

When PC Expo moves over to New York's Jacob Javits Convention Center next year, it will undoubtedly enjoy such amenities as better elevators and maybe a more accessible convention office, better signs (trying to coordinate the floor map in the book with the position of the booths was an exercise in the fifth dimension), and permanent press quarters equipped with telephones and typewriters.

But it will be hard to forget images from the Coliseum such as the hot-dog stands, cities of refuge where an exhibitor could lean against a concrete-block wall and munch a pale pink hot dog in one hand and sip gray coffee from a paper cup in the other—utterly, blessedly, ignored.

Laurence Altman

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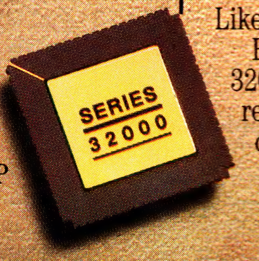

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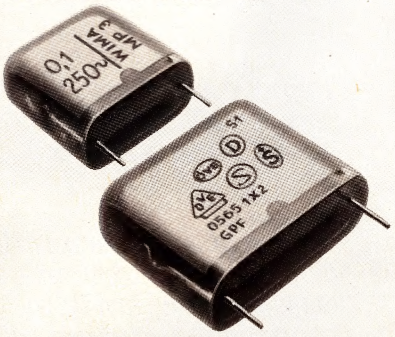

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MEETINGS

AACC Trends '85 Conference, Association of Agricultural Computing Companies (Cara Doyle, 146 E. Milwaukee St., Jefferson, Wis. 53549), Abbey Hotel, Fontana, Wis., Aug. 1-2.

International Symposium on New Directions in Computing, Institute of Electrical and Electronics Engineers (New Directions in Computing, P.O. Box 639, Silver Spring, Md. 20901), Norwegian Institute of Technology, Trondheim, Norway, Aug. 12-14.

Ausgraph '85, Australasian Computer Graphics Association Inc. (P.O. Box 29, Parkville, Victoria, Australia 3052), Crest International Hotel, Brisbane, Australia, Aug. 12-16.

Computer Graphics '85 East, National Computer Graphics Association (8401 Arlington Blvd., Fairfax, Va. 22031), Bayside Convention Center, Boston, Aug. 13-15.

Second International Forum on Micro-Based CAD, Autodesk Inc. (Colorado State University, Department of Industrial Sciences, Fort Collins, Colo. 80523), Colorado State University, Fort Collins, Aug. 14-16.

Seventh Conference of The Cognitive Science Society, Cognitive Science Society (1845 S. Elena Ave., Redondo Beach, Calif. 90277), University of California at Irvine, Aug. 15-17.

29th International Technical Symposium on Optical and Electro-Optical Engineering, Society of Photo-Optical Instrumentation Engineers (P.O. Box 10, Bellingham, Wash. 98227-0010), Town and Country Hotel, San Diego, Aug. 18-23.

28th Midwest Symposium on Circuits and Systems, University of Louisville (Electrical Engineering Department, University of Louisville, Louisville, Ky. 40292), The Galt House, Louisville, Aug. 19-20.

International Machine Tool Research Forum, National Machine Tool Builders' Association (7901 Westpark Dr., McLean, Va. 22102), Hyatt Regency O'Hare Hotel, Chicago, Aug. 20-21.

Eighth International Conference on Production Research, International Foundation for Production Research *et al.* (Fraunhofer Institute for Production Technology, Nobelstrasse 12, P.O. Box 800 469, 7000 Stuttgart 80, West Germany), University of Stuttgart, Stuttgart, Aug. 20-22.

CAEDEX '85—International Conference and Exposition on CAE Workstation Technology, CMP Publications Inc. (Access Conference Associates Inc., P.O. Box 160, Gaithersburg, Md. 20877), Long Beach Convention Center, Long Beach, Calif., Aug. 20-23.

14th International Conference on Parallel Processing, Pennsylvania State University and IEEE (IEEE Computer Society, P.O. Box 639, Silver Spring, Md. 20901), Pheasant Run Resort, St. Charles, Ill., Aug. 20-23.

Worldesign '85/ICSID USA, Industrial Designers Society of America, (Design Foundation, 1360 Beverly Rd., McLean, Va. 22101-3671), Sheraton, Washington, Aug. 20-24.

Advances In Impactless Printing, Institute for Graphic Communication Inc. (375 Commonwealth Ave., Boston, Mass. 02115), Holiday Inn on the Beach, Monterey, Calif., Aug. 25-27.

VLSI '85 International Conference, International Federation for Information Processing (Business Center for Academic Societies, 4-16 Yayoi 2-chome, Bunkyo-ku, Tokyo 113, Japan), Keidanren Kaikan, Tokyo, Aug. 26-28.

Seventh International Symposium on Computer Hardware Description Languages and their Applications, International Federation for Information Processing *et al.* (Tohru Moto-oka, University of Tokyo, Hongo, 7-chome, Bunkyo-ku, Tokyo, Japan), Keidanren Kaikan, Tokyo, Aug. 29-31.

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Unix/Xenix Seminar, Center for Advanced Professional Education (1820 E. Garry St., Suite 110, Santa Ana, Calif. 92705), Registry Hotel, Bloomington, Minn., Aug. 5-6; Marriott Inn-East, 2124 West Hamilton Rd., Columbus, Ohio, Aug. 7-8.

Fiber Optic Communications Systems, University of California, Santa Barbara (University of California Extension, Santa Barbara, Calif. 93106), Engineering Building, UCSB, Aug. 5-9.

ESD Control Course, SAR Associates Inc. (RR 2, Box 500, Rome, N.Y. 13440), Marriott Hotel, Pittsburgh, Aug. 6-7.

Fiber Optics Markets, Information Gatekeepers Inc. (Bob Casey, Information Gatekeepers Inc., 214 Harvard Ave., Boston, Mass. 02134), Logan International Airport, Boston, Aug. 21.

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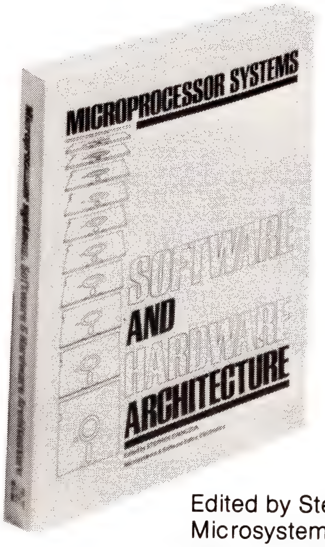

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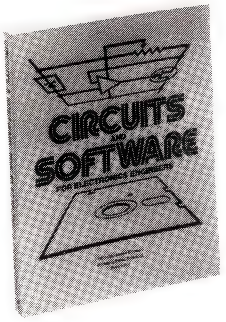

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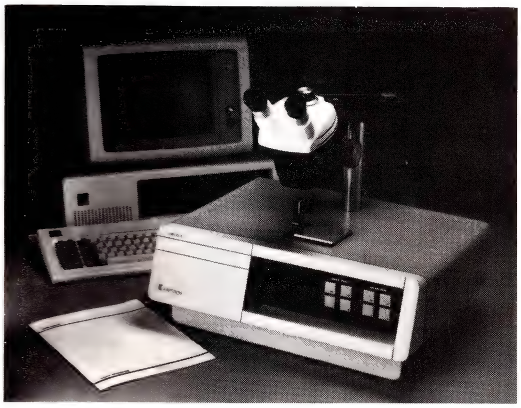

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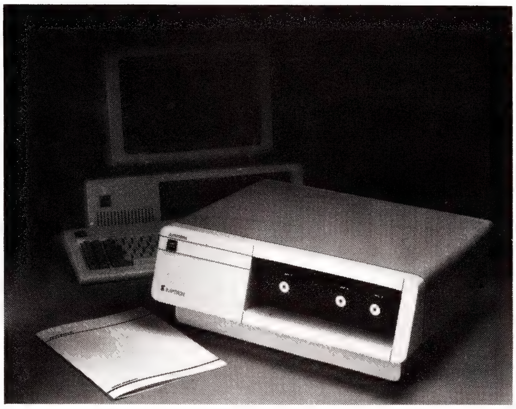

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MAJOR PRODUCTIVITY BOOST NEARS FOR COMPLEX-SYSTEM PROGRAMMERS

After five long years of product development, a Sunnyvale, Calif., startup named Rational is reportedly close to announcing an innovative software-development system that could speed up the writing of Ada code for complex systems by one to two orders of magnitude. Sources say the new system is aimed at large-scale programming projects, such as NASA's ground-based support systems, where software requirements have gotten out of hand. The amount of code NASA needs for these systems has grown at 25% annually over the past two decades, but programmer productivity rose only about 6% annually during that period. An incredible 20 million lines of computer code will need to be written to support NASA's upcoming orbiting space station.

Rational, which has kept a low profile, was established in 1980 by two Air Force Academy graduates, Paul Levy and Michael Devlin. ☐

IBM, IN TELECOMMUNICATIONS MOVE, SWAPS SBS FOR STAKE IN MCI

If a complex merger agreement between IBM Corp. and MCI Communications Corp. wins Justice Department and Federal Communications Commission approval, IBM would gain an initial 16% share of the No. 2 long-distance carrier while MCI would acquire debt-free most of the assets and operations of IBM's partially owned Satellite Business Systems venture. Under the terms of the agreement announced last week in Washington, MCI will give IBM 45 million shares and an option to increase its MCI ownership to 30% over the next three years. In exchange, IBM would assume all of SBS's outstanding debt—which totaled $400 million—and turn over to MCI three SBS satellites, 21 switching centers, and more than 200,000 customers. IBM, which has also agreed to buy the 40% stake in SBS owned by Aetna Life & Casualty Co., will retain three satellites and the SBS Real Estate Communications Corp. unit, in McLean, Va.

Though IBM said it would not boost its MCI holdings beyond 30% without MCI's approval, there was immediate speculation about such a move. "They said they wouldn't [acquire the whole company] with Rolm, and they did," notes Harry Edelson of Edelson Technology Partners, Saddle Brook, N.J. IBM initially purchased a 15% stake in Rolm Corp. and then acquired the rest of the telecom-equipment maker. "I think, long term, IBM will still take all of MCI," concurs telecommunications analyst George Dellinger, of Washington Analysis Corp. Moreover, Edelson sees the merger as the completion of an IBM triad that includes part of Intel Corp. and ownership of Rolm.

The key to distributed data processing is long-distance transmission networks, industry observers say. The merger will provide IBM with access to MCI's extensive optical-fiber and digital-microwave network, thereby making IBM a formidable competitor for AT&T Co. "It's obvious that [IBM] targeted telecommunications to augment their business," says Edelson. But IBM vice chairman Paul J. Rizzo plays down the deal's competitive aspects. "I find it hard to believe that by this move we are going to go to the heart of AT&T's business," he said at the news conference.

Rizzo says IBM decided to seek an SBS-MCI merger rather than continue to pour substantial amounts of money into SBS over the next three years to make it profitable. "We would prefer to put that extra investment into MCI rather than SBS." IBM, Aetna, and former partner Communications Satellite Corp. have spent $1.3 billion on 11-year-old SBS, but the firm has yet to turn a profit. Rizzo says possible future ventures between IBM and MCI may include "large, complex telecommunications bids" to provide government agencies with complete networks.

MCI initiated business talks with IBM two months ago because "we saw combinations taking place in the [telecommunications] industry," says MCI chairman William G. McGowan. Characterizing the merger as "an enhance-

ELECTRONICS NEWSLETTER

ment of competition in the telecommunications industry," McGowan says that MCI would begin linking SBS to MCI's extensive terrestrial network as quickly as possible. Though MCI shareholders stand to gain the most from the deal, analysts say, the big losers will likely be long-distance carriers such as GTE/Sprint, Allnet, and other smaller telecommunications firms that may now feel pressure to follow MCI's lead. ☐

JAPANESE CHIP MAKERS TRIM 1985 CAPITAL SPENDING

Japanese semiconductor manufacturers plan to cut their fiscal 1985 capital spending by close to $1.2 billion, according to a survey by the Ministry of International Trade and Industry. The survey revealed that the reduction—to a 1985 total of $2.42 billion—represents a 20.6% drop from 1984. Chip vendors have deferred further capacity increases until at least fiscal 1986. ☐

RCA WORRIES THAT SKY-HIGH VCR INVENTORIES WILL CAUSE A SHAKEOUT

A giant in video cassette recorders, RCA Corp., is "extremely concerned" about the backlog of VCRs in U.S. warehouses, reports Frank McCann, vice president of public affairs for the New York firm's Consumer Division in Indianapolis. Industrywide, between 15 million and 16 million units could hit these shores from the Far East in 1985, but projections pin sales at only 11 million this year. In response, RCA has already delayed shipment of $50 million worth of VCRs from its overseas suppliers. U.S. VCR sales in June were up about 30% over last year—down substantially from the over-60% pace the industry has gotten used to, but robust all the same. One positive consequence of the downturn could be "a more orderly market if a slack demand for VCRs eliminates some of the 68 brands now competing for their share," McCann says. A spokesman for Matsushita Electric Industrial Co. expresses a different outlook, however. "All the smaller manufacturers have to do is capture a 1% to 1½% share of a market that's [still] growing at 30% to 40% in order to stay in business. Big names must work harder to keep their share of a pie that won't be growing as fast as we're used to." ☐

INTEL ASKS COURT JUDGMENT ON MICROCODE COPYRIGHT PROTECTION . . .

The vitriolic dispute over the sanctity of microcode, which began in December between Intel Corp., Santa Clara, Calif., and NEC Corp., Tokyo, is heating up. Last week, Intel attorneys asked a U.S. District Court judge in San Jose, Calif., to determine whether microcode has copyright protection. The hearing was the first since NEC, in a suit filed against Intel in December 1984, asked the court to decide if NEC had violated copyright laws with its V20 and V30 microprocessors, designed to operate in place of Intel's popular 8086 and 8088 chips. Intel countersued in February, claiming that NEC had indeed violated its copyrights with its V-series. "The problem is that all legitimate companies in the industry look at [microcode] as copyrighted subject matter," says Gene Cohen, counsel for Intel, pleading for an immediate judgment on the issue. "Now NEC has allowed uncertainty to take hold of the industry." The court will probably ask for cross-examination of experts for both companies, but it could reach a decision by the end of July. ☐

. . . AND LAYS OFF NEARLY 1,000 WORKERS

With the semiconductor industry undergoing "the most severe shakeout in our industry in over a decade," according to chairman Gordon E. Moore, Intel Corp. last week said it is laying off almost 1,000, or 4%, of its 24,000 employees. The Santa Clara, Calif., firm said remaining workers might find themselves with seven days off without pay in this year's third quarter. ☐

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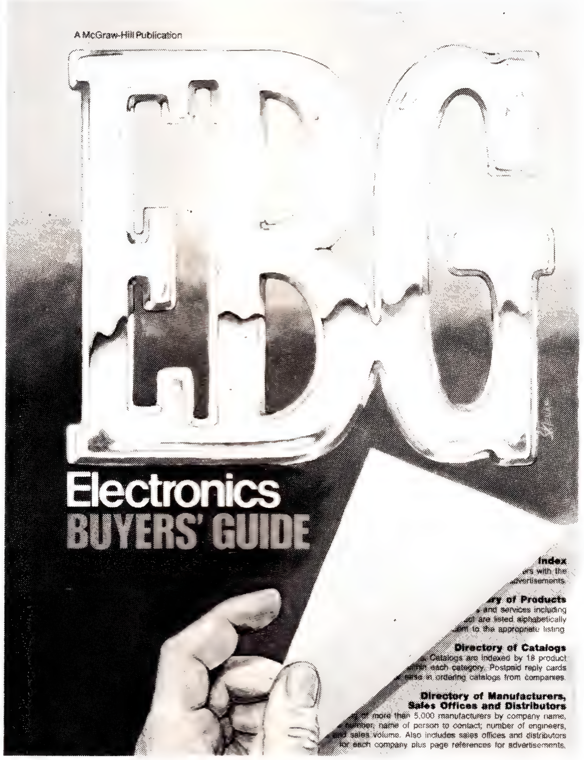
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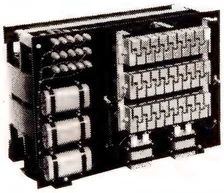

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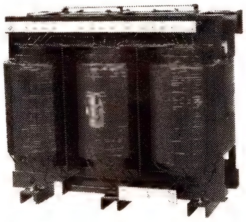

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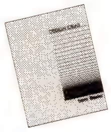

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THIS Electronics WEEK

THURSDAY *June 20*

Although participation in summer shows is down (see p. 22), two of the world's largest computer societies are resurrecting a familiar conference name from the 1950s and '60s. **The IEEE Computer Society and the Association of Computing Machinery said today that they will host a Fall Joint Computer Conference** at the Infomart complex in Dallas next year. The sponsors expect between 6,000 and 10,000 people to attend the conference, which they say will differ from such shows as the National Computer Conference in that it will include 10 to 15 concurrent conferences focusing on state-of-the-art technologies across the entire computer industry. The show's purpose is "helping people focus their way into the 1990s," says Stanley Winkler, chairman of the 1986 meeting. A call for papers should come in mid-July, possibly at the NCC during the week of July 15.

FRIDAY *June 21*

In a move to purchase a company nearly 10 times its size, Dallas's **Sterling Software Inc. reached an agreement to acquire Informatics General Corp. for nearly $135 million.** The deal to buy Informatics, a Woodland Hills, Calif., software firm, came several days after reports surfaced that Sterling Software chairman Sam Wyly was actively seeking control of Datapoint Corp. Wyly had been interested in acquiring assets from the San Antonio, Texas, computer firm for his closely held Netamerica Corp., in Dallas, according to a federal suit filed against ousted Datapoint executive John C. Butler (see p. 26). A spokesman for Sterling Software says merger efforts with Informatics General had been under way for months, and the timing of the agreement was unrelated to the dealings of any other of Wyly's business ventures.

MONDAY *June 24*

In a departure from the recent layoffs in Silicon Valley, **computer manufacturer Convergent Technologies Inc. announced a recruiting program to attract "superachievers,"** according to a company representative. "The time seems right, as well, in light of engineering cutbacks at other technology companies, and in the shortage of opportunities for recent engineering graduates." The announcement lifted hiring restrictions adopted just last month. The San Jose, Calif., company currently has 1,839 permanent employees and last year generated revenues in excess of $200,000 per employee.

TUESDAY *June 25*

NCR Corp. introduced a 32-bit microcomputer based on the Motorola Corp. 68020 microprocessor and AT&T Bell Laboratories' Unix operating system. The computer, called the Tower 32, can support up to 32 interactive users, and will list for $21,900 in a basic configuration that includes 1 megabyte of main memory and 45 megabytes of disk storage. The announcement marked NCR's third Tower-family introduction in eight months.

WEDNESDAY *June 26*

Amdahl Corp. introduced a pair of supercomputers, extending its family of vector processors to four. The Sunnyvale, Calif., computer maker's model 1400 runs at up to 1.14 gigaflops and has 256 megabytes of main memory; the model 500 runs at 133 megaflops and has half the main memory of the 1400. . . . Computer maker **Gould Inc. said it would take a $150 million special writeoff in the year's second quarter.** Excluding the writeoff, the Rolling Hills, Ill., company said earnings were down 15% from a year ago. ☐

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Process points to power-stingy complementary GaAs chips running at n-channel speeds

Minneapolis

Researchers at Honeywell Inc. have come up with a process that alleviates a major stumbling block to producing complementary gallium arsenide integrated circuits. Within five years, the researchers expect, commercial GaAs circuits will be possible that match today's fastest n-channel GaAs circuits in speed but dissipate as little as one tenth the power.

GaAs has won its place in the IC arena because electrons travel in the material about six times as fast as they do in silicon, making possible very fast n-channel devices. However, adding the blessing of low power consumption, as has been done with CMOS structures in silicon, is not so straightforward. Positively charged holes in GaAs have about one twentieth the mobility of electrons, so speed has to be sacrificed when adding the p-channel transistors needed for low-power complementary chips.

For this reason, most chip makers have shied away from complementary structures in GaAs. With Honeywell's announcement, however, a change in attitude seems in the offing.

What's more, the upcoming very large-scale ICs could be made to take full advantage of GaAs's inherent speed. By contrast, chips made with the GaAs technologies that are on industry pilot lines today would burn up if extended to their full speed advantage at VLSI densities, Honeywell says.

In the burgeoning world of GaAs-circuit acronyms, Honeywell is calling its new device a HIG FET (for heterostructure insulated-gate field-effect transistor). The firm's Physical Sciences Laboratory built its first working HIG FETs last March; it expects soon to sign a contract with the Wright-Patterson Air Force Base Avionics Laboratory to develop the technique further. By the end of the 16-month contract period, Honeywell hopes to be producing 64-bit HIG FET-based random-access memories, says Nicholas Cirillo Jr., supervisor of the Honeywell lab's Gallium Arsenide Digital Electronics Section. The Air Force research and development contract could amount to between $200,000 and $250,000 and is tentatively set for signing this month.

Upcoming VLSI circuits could take advantage of GaAs's speed

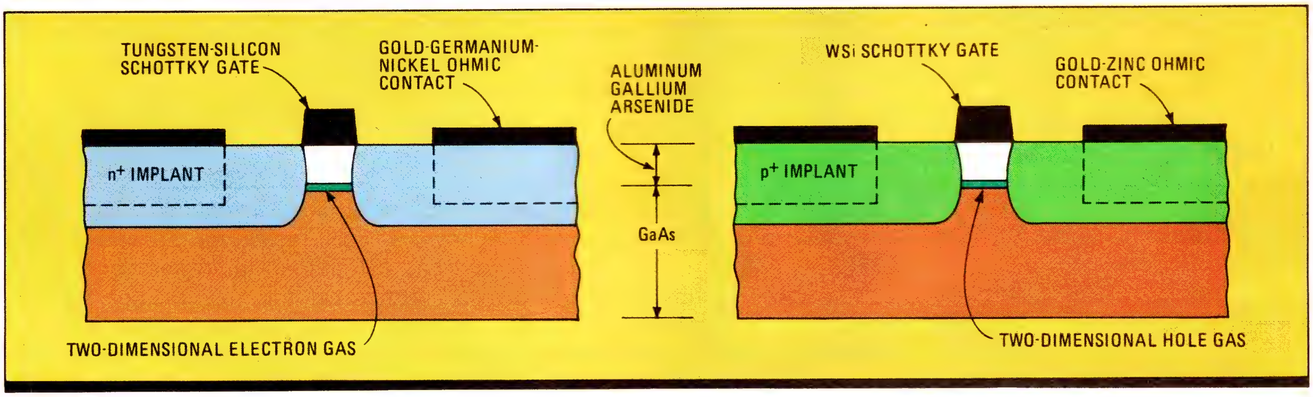
Similar to self-aligned. The HIG FET process is similar to the planar self-aligned-gate approach used by Honeywell to fabricate the recently reported MOD FETs (for modulation-doped FET) that set a record for the fastest semiconductor transistor yet demonstrated [*Electronics Week*, May 13, 1985, p. 19]. (The MOD FET is more commonly known as HEMT, for high-electron-mobility transistor, though AT&T Bell Laboratories refers to its similar technology as SDHT, for selectively doped heterojunction transistor.)

Like Honeywell's MOD FET, the HIG FET relies on an aluminum-gallium arsenide layer grown by molecular beam epitaxy atop a similarly formed layer of pure GaAs to form a heterostructure device. But unlike the doped AlGaAs in the MOD FET, the 300- to 500-Å-thick AlGaAs layer in the HIG FET is undoped. This allows the use of a selective-ion-implantation process employing both n- and p-type dopants to form the n- and p-type transistors in the same circuit.

Other firms have fabricated similar heterostructure-based circuits using n-channel FETs alone, says Cirillo. "But no one has taken it the extra step by also making p-channel devices in the same circuit to get complementary logic," he states.

Junction FET. Only one other manufacturer, McDonnell Douglas Astronautics Co., Huntington Beach, Calif., is pursuing complementary GaAs as a main approach. The firm is now delivering 1-K static RAMs using its complementary J-FET (for junction FET) approach and is working on 4-K versions under a contract with the Pentagon's Defense Advanced Research Projects Agency.

But unlike the heterostructure-based Honeywell device, in which the AlGaAs and GaAs layers are grown by MBE, the J-FET circuits rely on a homostructure approach. In this technique, the pn junctions are ion implanted in a bulk GaAs layer. This means that the already slow hole mobility in the J-FET is impeded even further by scattering be-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GOLD-ZINC OHMIC CONTACT
n+ IMPLANT
p+ IMPLANT
GaAs
TWO-DIMENSIONAL ELECTRON GAS
TWO-DIMENSIONAL HOLE GAS

Paired off. Selective implants in undoped layers of AlGaAs and GaAs achieve the p- and n-channel devices to match CMOS circuits.

cause of collisions with the dopants where the current must flow.

In the Honeywell HIG FET, by contrast, the current flows in the pure MBE-grown GaAs layer. Thus, unimpeded by dopants, both electrons and holes can move more rapidly.

"When we go to a complementary approach [in the J-FET], we get lower power dissipation, but we also give up speed," concedes Rainer Zuleeg, a research fellow at the McDonnell Douglas Microelectronics Center. The Honeywell approach, he agrees, sounds like a promising technique for equaling the 100-ps gate propagation delays typical of n-channel-only GaAs circuits, while maintaining low power dissipation.

At Honeywell, Cirillo says power dissipation for ICs built with HIG FETs could come in at one fifth to one tenth that of typical n-channel-only GaAs circuits. McDonnell Douglas's J-FETs hold power dissipation to the same range but suffer lengthier propagation delays of between 250 and 300 ps, Zuleeg indicates.

Discretes so far. To date, Honeywell has built only discrete HIG FET circuits and HIG FET-based inverter stages using 1-μm minimum geometries. The firm has not yet fabricated ring oscillators using HIG FETs, in which actual propagation delays can be measured. But initial HIG FET circuits have exhibited p-channel transconductance of 28 millisiemens per millimeter at room temperature and 59 mS/mm at 77 K, Honeywell reports. This is two to three times the figure reported for the McDonnell Douglas J-FETs, which show room temperature p-channel transconductance from 5 to 10 mS/mm.

"We haven't run them cold," says Zuleeg. But he estimates the number would increase by a factor of two or three for J-FETs operated at 77 K.

Companies including NTT in Japan, Bell Labs, and IBM have demonstrated experimental GaAs circuits with p-channel transconductance in the range of 35 to 46 mS/mm at 77 K. But the Honeywell numbers are believed to be the best yet. With further development under the expected Air Force contract, Cirillo says that HIG FET p-channel transconductance could improve even further. "We believe that we can get the p-channel [transconductance] at room temperature up to about 100 mS/mm."

Honeywell's numbers are believed to be the best yet reported

As it stands now, even the improved HIG FET p-channel mobilities are much slower than for its n-channel counterparts. Honeywell reports HIG FET n-channel transconductance at 218 mS/mm at room temperature, with 77 K measurements pegged at 385 mS/mm. As with silicon CMOS circuits, this disparity forces the p-channel devices to be built wider than the n-channel devices to achieve proper transistor matching.

Graded structure. The trick for further improving HIG FET p-channel transconductance will involve a graded AlGaAs structure in the MBE-grown layer. This technique involves increasing the aluminum concentration near the AlGaAs/GaAs interface to produce more carriers (holes or electrons), according to Cirillo.

Current industry practice is to maintain about a 70% : 30% ratio between the gallium and the aluminum uniformly in the AlGaAs layer. This avoids possible oxidation problems at the surface of the layer with excessive aluminum concentrations. Graded MBE structures with higher aluminum concentrations near the interface "would let you increase your carrier density, which translates into increased transconductance," Cirillo points out. *–Wesley R. Iversen*

SEMICONDUCTORS

ROBOT-RUN PLANT IN THE WORKS

Somerville, N.J.

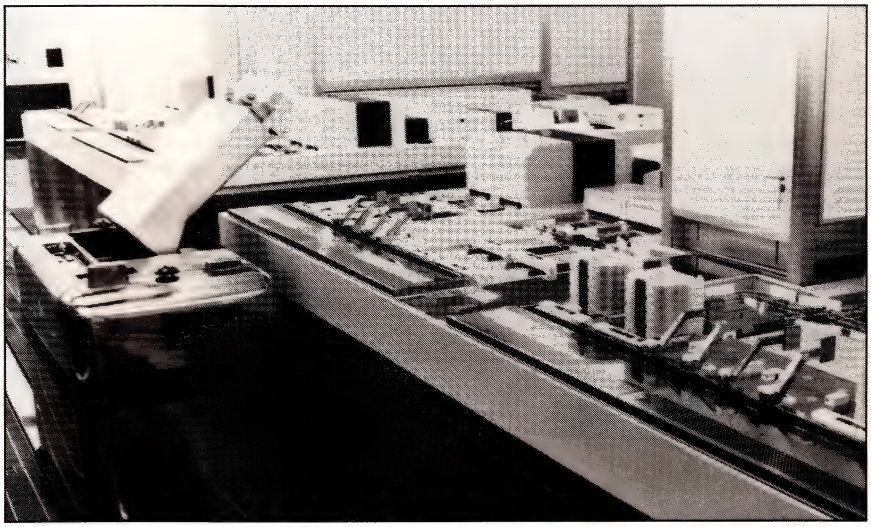
The quest for ever denser CMOS-circuit geometry is a driving force behind the creation of RCA/Sharp Microelectronics Inc., a 51%-49% joint-equity venture between the two electronics giants. The other is an effort to utilize and expand advanced production facilities for wafer fabrication.

"We [RCA's Solid State Division] have visited a number of wafer-fabrication facilities throughout the world and feel that Sharp's plant in Fukuyama, Japan, stands among the best in terms of automation and levels of defect density," says Jon A. Shroyer, former vice president for large-scale-integration products and technology development at RCA's Solid State Division and now president and chief executive officer of the joint venture.

Clean-room leaders. "Cleanliness is next to godliness in this business," says Ken Gooen, director of advanced development and analysis at the Solid State Division. "Any particulate at all is a potential threat to our yield. Right now, the Japanese are the leaders in clean-room technology—but after a while, people share ideas and we learn what to do. When the joint venture starts manufacturing in earnest, it will use rooms without people for wafer fab."

For its part, Sharp is seeking design expertise in CMOS technology. "Our focus is on CMOS because we feel it is the technology of the 1990s," explains Atsushi Asada, senior executive director of Sharp's Integrated Circuit Group. "That's why we chose RCA as a partner. Their design capabilities and the breadth of their CMOS product line and semicustom software are especially impressive."

"Sharp has the robots and RCA has the software-design methodology," says H.S. Miller, manager of design-systems engineering and semicustom-device operations at RCA. "We have 100 megabytes of stabilized code, so we can use the same design techniques for the joint



Hands off. In Sharp's Fukuyama integrated-circuit plant, only robots touch the wafers.

venture as we're using in our own semicustom facilities."

Sharp's plant at Fukuyama and the Sharp engineering center at Tenri will serve as pilot facilities for translating the circuits developed by both RCA and Sharp into manufactured products—40% of which will be semicustom designs. The know-how gained in Japan will serve to test the techniques for advanced manufacturing that will be used eventually by the joint venture.

Sharp has the robots, RCA has the software

Construction will begin on the new RCA/Sharp Microelectronics facilities at the end of this year in Camas, Wash., a site chosen as much for its seismic stability as for its potential to attract young engineers (who will presumably be enticed by the outdoor life of the Columbia River valley and the cultural opportunities of nearby Portland, Ore.).

Quake proof. "Sharp and RCA are developing techniques that will soon be shrinkable to submicron chip geometries," says Gooen. "At such small IC path dimensions, the slightest tremor can wreck a production run."

In addition, the atmosphere in the clean rooms has to exceed Class 10 [*ElectronicsWeek*, Oct. 15, 1984, p. 11]. Borrowing from the heavy robotization of the Fukuyama plant, all material delivery to the Camas facility will be automatic; no human hands will touch the wafers or their carriers. Inspections will be made on a sample basis to provide statistical process-control data.

The Camas plant eventually will consist of a design center and a wafer-fabrication facility. Work will begin at the design center at the end of the summer; construction of the wafer-fab plant will begin at the end of the year and production of 6-in. wafers will start early in 1987. When the line ramps up in 1989, the plant will employ 650 people and account for 750 wafer starts per day, around the clock. Until then, the design center's ideas will be tested in Fukuyama.

Shroyer appears unconcerned by the recent downturn in the semiconductor market. "The growth of CMOS will make it the dominant technology of the IC industry in the 1990s. This provides a great opportunity."

In 1984, RCA had $200 million in CMOS sales and Sharp $130 million, but with total CMOS industry volume expected at $28 billion by 1990, both companies expect plenty of revenue for their joint venture. *–David M. Weber*

SOFTWARE

FLAW IN 286 CHIP SNAGS CONCURRENT-DOS MODULE

Pacific Grove, Calif.

The chips are down for the modular Concurrent DOS 286 operating system. Digital Research Inc. had hoped the system would make a mark among original-equipment manufacturers in need of real-time multitasking capabilities that can be tailored to suit the application.

Nine months ago, as the firm was developing the operating system for computers based on Intel Corp.'s 80286 microprocessor, it uncovered a flaw in the chip that was fatal to an optional front-end module that emulates PC-DOS, the operating system used in the IBM Personal Computer. So as it continues to move ahead on the rest of the package, Digital Research is eagerly awaiting the chip's corrected version—what Intel calls the DA stepping. Samples should be forthcoming in July, but production copies might not be available until months later.

The 286 has gone through several steppings since it first hit the market. Digital Research was using the B1 stepping when it began development of Concurrent DOS 286. But when they began receiving 286s from the B2 stepping in September and October 1984, things started going wrong.

DRI is the only software company to run into this problem, says Donato De Philippis, Intel's product marketing manager for the 286. He points to what he says is an unusual technical strategy the firm is using. "Essentially, they generate on purpose an exception," he says, which under some circumstances can result in corruption of the data in the processor's C register.

A bug prevents full use of the chip's power

Full power. But DRI is not trying to pull some fancy stunt with the processor. Simply put, it is writing an operating system that attempts to make use of the full power of the 286 while taking Intel at its word that the chip can, in its more powerful mode, execute object code originally generated for the 8086 or 8088 processors.

The 286 has two modes of operation—the real-address mode and the protected virtual-address mode. In the real-address mode, the 286 acts very much like its more limited predecessor, the 8086; it can address only a single megabyte of memory, and it can, in fact, execute 8086 object code. When an IBM PC AT runs under PC-DOS 3.0, the 286 processor stays in this mode.

But the real power of the 286 comes through in the protected mode, where it can address a physical memory of 16 megabytes and a virtual memory of 1 gigabyte. This mode, as the name implies, also brings into play a four-privilege-level scheme for protecting data.

Intel wanted a full superset of the 8086 instruction set to be available in the protected mode. But with the B2 stepping of the chip, instructions such as the one that moves the contents of the segment register to physical memory and segment-arithmetic instructions such as the one that increments the segment register by 1 sometimes corrupt the contents of the C register.

First release soon. Concurrent DOS 286, scheduled for introduction Aug. 27, uses the 286 in its protected mode. An optional front end that emulates Microsoft Corp.'s PC-DOS operating system, for which there is so much application software, is planned for later release.

But that emulating front end for the modular, real-time, multiuser, multitasking Concurrent DOS 286 will not be useful until systems built around the fixed 286 processor hit the market—sometime in 1986, at the earliest. This delay concerns Digital Research. "It postpones a lot of revenue," says Dan Erickson, product marketing manager.

Microsoft's Xenix is one operating system that uses the 286 in the protected mode. But because 8086 object code can't be run successfully in protected mode with the flawed 286, Microsoft cannot offer an emulation mode that allows Lotus's 1-2-3 and other applications written for the IBM Personal Computer to be used under Xenix. Such a capability would go a long way toward relieving the shortage of software for the Xenix environment. However, as John Sabol, group marketing manager for operating systems at Microsoft, says, "We don't have any announced products that depend on that flaw being fixed."

The fix is in the microcode for the 286's exception handler. De Philippis emphasizes that Intel has done extensive simulation to ensure that the microcode changes will not influence the chip's operation in any way that will affect other vendors' software.

Another factor in the evolution of the 286 may delay the volume production of the DA stepping: the transition from fabrication in the 2.2-μm high-performance MOS II process to fabrication in 1.5-μm H-MOS III. The change will result in a die about 30% smaller than the present one. It also will allow Intel to produce parts operating with 10- and 12-MHz clocks, rather than the 6- and 8-MHz parts now available.

Samples of the latest stepping on the market, C2 in H-MOS III, are already available, says De Philippis. But before the 1.5-μm parts go into full production, Intel must shrink the new DA stepping to H-MOS III dimensions. Therefore, the faster part and the fixed part must be merged before either can go to market. Meanwhile, DRI will take its new operating system to OEMs and value-added resellers without its PC-DOS emulation option. *–Jeremy Young*

HOME COMPUTERS

MSX HOME COMPUTER GETS A NEW LOOK

Tokyo

Although it is the best-selling home computer in Japan, MSX is by no means a standout in performance. So the group backing the MSX hardware and software standard—U.S. software house Microsoft Corp. and a score of hardware makers in Japan and Europe—has developed an upscale version of the basic machine to cement its Japanese standing and perhaps to penetrate the much larger U.S. market.

Screen test. MSX2 version of Japan's best-selling computer boasts greatly improved bit-mapped graphics.

MSX2 outperforms its predecessor [*Electronics*, June 30, 1983, p. 48] through its significantly improved graphics and its one-way compatibility with CP/M, the most widely used operating system for 8-bit microcomputers. Because of the new compatibility, points out Yoshifumi Hamada, an executive of ASCII Corp. (Microsoft's agent in Japan), MSX manufacturers can offer features that match those of heavy-selling home computers in the U.S. and tap an abundant pool of software.

Two manufacturers, Toshiba Corp. and Nippon Gakki Co., best known by its brand name Yamaha, already have MSX2 machines on the market. These sell for around $400, almost twice the price of a bottom-of-the-line first-generation Yamaha MSX. The other manufacturers in the group could have products on the market by the fall. So far, the group has turned out about 650,000 MSX machines in Japan and some 250,000 in Europe and Korea.

Twice the text. The new design uses an 80-column screen with lines of 512 pixels across, compared to 40 columns of 256 pixels. The number of pixels in the vertical dimension has also been increased to 212 from 192. Therefore, in addition to doubling the number of characters (including Chinese kanji) on the display, the MSX2 can handle the 204 dots of Japanese and North American videotext, with an additional line for commands.

For a computer to boast good graphics in today's market, however, it has to have more than just sharp text. So the new MSX standard calls for 128-K of video random-access memory, with at least 64-K installed at the factory and sockets for the remaining 64-K. That compares with 16-K of video RAM in original MSX machines.

Just as important, the upgraded design uses the new V9938-MSX video chip, developed in a group effort by Microsoft, ASCII, and Nippon Gakki's Electronics Systems Division. Upwardly compatible with the previously specified chip, Texas Instruments' TMS9918, the new one makes possible color-palette and bit-mapped graphics modes as well as frame-grabbing, digitizing, and superimposing functions.

The new machine has a main memory of 64-K minimum; a real-time clock similar to those in the latest professional personal computers, such as the IBM Personal Computer AT, is built in. The 32-K Basic interpreter read-only memory has been upgraded to 48-K with additional commands for graphics, password, date, and time, among others.

There are also hardware and software interfaces for a mouse, trackball, light pen, 3½-in. floppy-disk drive, printer, modem, and RS-232 communications. For storage, it has a single-sided floppy disk with a 360-K-byte capacity.

Tempered by technology. Despite complaints of a stagnant computer market, much of the improvement has been made possible by such recent developments as slashed memory prices, the wide availability of TV sets with red-green-blue video inputs at moderate prices, and the proliferation of low-priced printers. Also, Nippon Telegraph & Telephone Co. has started its Captain videotext service and the Ministry of Posts and Telecommunications is putting the finishing touches on a standard for electronic mail.

Although MSX2 specifications were not in final form until May, two firms, Toshiba and Yamaha, are already selling their first versions. Yamaha's computer features 128-K of main RAM as well as 128-K of video RAM, while Toshiba's has an internal slot for an optional RS-232-C board. Matsushita Electric Industrial Co., Canon Inc., and Sanyo Electric Co. have shown prototypes with separate keyboards that do have a 10-key pad and built-in drive in the chassis. *–Charles L. Cohen*

COMPONENTS

SURFACE MOUNTING: HANDLE WITH CARE

Boston

Engineers who dream of packing ever more components onto boards with surface-mounting technology are in for a shock—or maybe a burn—if they try to touch one of those fantasy boards. The technology will allow greater density, but it requires new approaches and attention to details that if ignored can make life with SMT extremely difficult.

Such warnings came out of the late-June Nepcon East meeting, as several hundred of the reported 16,000 attendees turned up for the technical sessions covering various issues in SMT. Many electrical engineers have been lulled by the similarities into overlooking the differences between conventional and SMT

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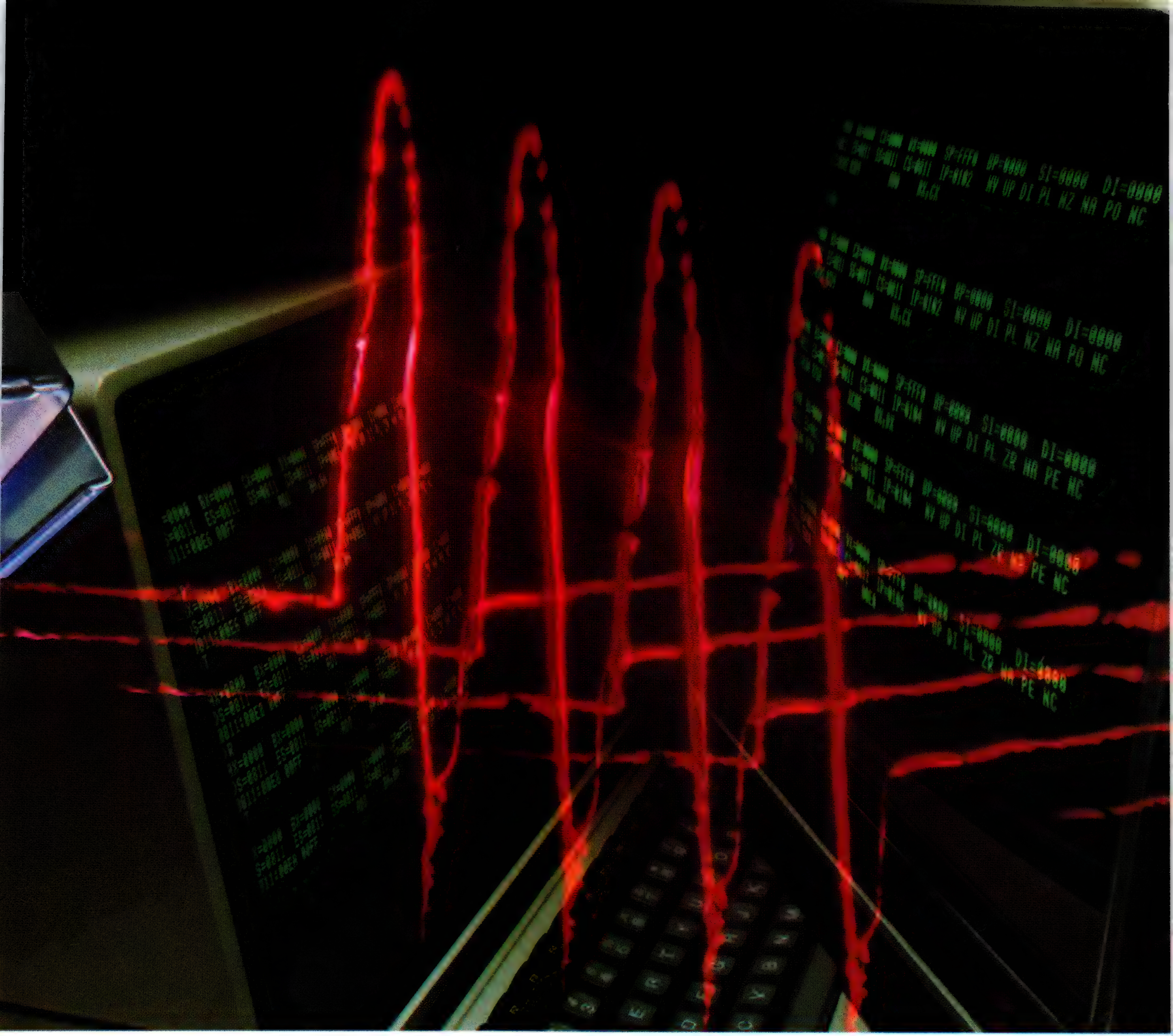

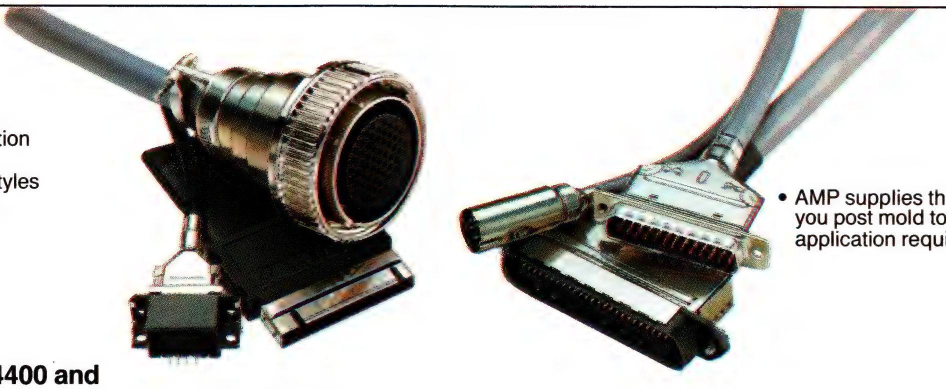

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design, SMT veterans agreed. Though the circuitry is similar, "the real change is primarily mechanical," points out Gregory Horton, senior project engineer at Sperry Corp.'s Commercial Flight Systems Division, Phoenix, Ariz.

For one thing, the increased density of surface-mounting boards creates much more heat. Horton said many electrical engineers "won't think twice about the fact that they're putting five times the power on a board. But we have to get rid of that heat." Problems of mismatched thermal expansion, which are an issue because of the many different SMT soldering techniques, have been largely resolved, said Horton, but the same tight schedules and "haywire" jumpering used on conventional boards won't work.

EEs should think of surface-mounting as a new technology

"The technology is deceiving," said Horton. "It looks like regular old circuit-card assembly. The shape is all the same, [but engineers] have to treat it as a change in technology."

Horton said manufacturing executives recognize the change a lot easier than engineers do because components cost approximately twice as much. He notes that there are also problems with component availability: "Parts are usually available but lead times are long."

Other difficulties arise with the quality of solder paste. One company makes excellent paste, said Horton, but 50% of its product is unusable because of poor quality control. Max Peel, president of Contech Research Inc., an Attleboro, Mass., firm that specializes in assembling SMT printed-circuit boards, said the tricks of the trade include finding the right solder paste and learning how to use it. "We don't prebake and we have no solder-ball problems," he said. "But the solder does have a shelf life and it's not three months. We think it's six weeks."

Coplanarity is crucial. Peel, who chaired the session on factory implementation, said other SMT production issues are the coplanarity of termination leads relative to each other, stand-off heights, lead finishes, termination types, and connectors. He finds coplanarity particularly important. "We go through hell with some devices because coplanarity is out," he said. If the coplanarity is too far off, say 5 mils or more, there may not be a solder joint. The best results are obtained when coplanarity is held to ±2 mils.

Joint advice. Contech's Max Peel says the right solder paste is essential for SMT.

Another minor factor that creates major hassles is stand-off height. This is the distance that components are raised above the substrate. Peel thinks stand-off heights should be a minimum of 25 mils. But most devices range between 5 and 10 mils, making proper flushing and agitation practically impossible.

Details also make big differences when it comes to connectors. Dave Brearley, business manager for E.I. Dupont de Nemours Connector Systems in Cumberland, Pa., said the mismatch of thermal coefficients between connectors and circuit boards requires compliant solder tails to avoid cracking. With SMT, "quality requirements are substantially higher," said Brearley. "In the past, if it didn't fit the [assembler] could jiggle it [to get the pins in], but not with SMT." But he disagreed with Peel on the need for tight coplanarity.

"Here's where I disagree with Max," said Brearley. "He asks us to make coplanarity within 2 mils, but it costs us a lot and I don't think it's worth it."

Total agreement. What all speakers agreed on was the need for more "up-front time," or time spent in the design phase to consider the manufacturability of a board. Mitch Davis, a unit manager in RCA Corp.'s Missile and Surface Radar Division, Moorestown, N.J., said, "You just can't take the regular old pc board and expect it to have the right traces for surface mount."

Peel adds that customers are becoming aware of the difficulties. When they contract with design houses for surface-mounted devices, he said, they are more frequently asking for working parts as well as designs. *–Craig D. Rose*

TRADE SHOWS

INDUSTRY SLUMP SOURS SHOW BUSINESS

Los Angeles

During boom times, the industry's flagship trade shows provide sizzle as well as sales leads. Even tiny firms go all out with elaborate exhibits and staged events. However, as business cools and companies pull back, these shows can fizzle, too.

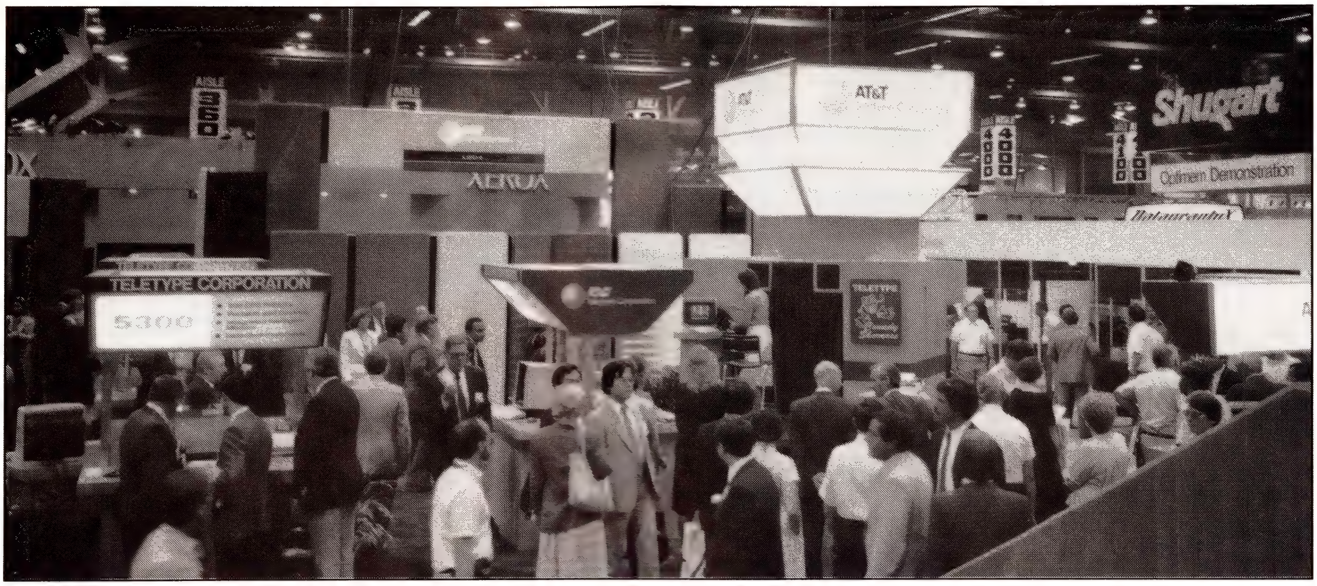
Right now, signs abound that these gatherings face their toughest times in years. The latest tip-off came from Info/West, staged in mid-June in Anaheim, Calif., for major customers of computer equipment and services. Of about 120 firms scheduled to exhibit their wares, more than 30 were no-shows, most notably Apple Computer Inc., Cupertino, Calif. Attendance also plummeted: manager Cahners Exposition Group claimed 12,000 attendees, less than half the 30,000 expected.

Over 30 out of 120 firms pull out of Info/West show

Moreover, the next scheduled premiere meeting—the National Computer Conference, to be held July 15-18 in Chicago—is also corralling fewer exhibitors than planned. So far, about 600 companies have signed up, compared with the 700 or so at the Las Vegas meeting last year, where 110° temperatures held crowds down to a 70,000 total.

In vivid contrast to the seller's market of the past few years, when every show filled up months in advance, firms now carefully choose which shows to attend, since the total tab can top $50,000. A Southern California advertising and public relations agency, which usually sends six clients to the NCC, for example, will send just two this year.

The Exhibit Place, Huntington Beach, Calif., said to be the largest designer, builder, and servicer of exhibit booths for computer industry shows, reports that only 13 clients will be at the NCC, down from 30 last year. Founder Tom Olhasso, cites bad business, weak markets, heavy show expenses, and the fact



Ebb and flow. Trade shows, crowded like this in boom times, are losing exhibitors and attendance now that times are tough.

that Silicon Valley companies are saving their resources for Fall/Comdex, closer to home in Las Vegas.

To get in step with the business cycle, show managers now have to shift gears into a hard-selling phase, advises a veteran of the field, Bruce S. Angwin, president and general manager of Electronic Conventions Management, Los Angeles. His company runs eight shows, including Wescon and Electro, which date back to the 1950s.

"This is the time when they have to effectively demonstrate the true value of trade shows to clients," says Angwin. What the shows do best for firms that understand the game is develop new business prospects.

But, he maintains, too many confuse selling events with such goals as seeking corporate identification by "flying the company flag, or going to a show only because you're afraid not to be there because of what competitors might say." These objectives are unrealistic and soon abandoned when budgets get tight.

Local draw. Another truth that Angwin's operation has found in researching its shows: attendance is largely regional, no matter the national character of exhibitors. About 80%, in fact, come from within 500 miles of the show's site. To Angwin, this means heavy regional promoting to ensure a flow of prospective buyers for exhibitors.

Though most shows may be fighting to stay even, Boston's Interface Group Inc. claims not to be feeling any pain at its twice-yearly Comdex. Led by president Sheldon Adelson, Comdex grew from virtually nothing at the beginning of the decade to become an outstanding success story, buoyed by the personal computer and its peripherals and software. The show is directed at value-added resellers or independent sales firms.

Adelson asserts that Comdex shows are still sold out and growing. He believes that his shows are insulated from the industry slump because of their long waiting lists. Specifically, he says Comdex/Spring in Atlanta sold out and drew 51,500, up from 50,000 a year earlier. Also, the fall show in Las Vegas and spring 1986 are sold out. "But I'm not naive enough to think I'm not affected in some way. Maybe later in 1986."

Indeed, Comdex may be affected sooner. Olhasso says Comdex usually draws up to 65 of the Exhibit Place's clients, and this year perhaps 50 will go. Officials at other shows scoff at Adelson's claims, given the accelerating decline in business. But even if Comdex exhibit totals hold up, Comdex attendance could suffer, they say, since the value-added business largely rests with small operators, who have been hard hit by the sales drop.

Though the end-user type shows, Info and NCC, are declining, those with an industrial orientation appear to be holding their own. Angwin's Wescon at San Francisco in November, for example, is sold out, with some 800 exhibitors. But he is taking nothing for granted, and continues to push promotion and other support.

Another end-user show, Syntopican, will be getting a face-lift next year from its sponsor, the Association of Information Systems Professionals (AISP). James J. Donio, director of public relations and special projects for AISP, says that trade shows today lack integration between events on the trade show floor and educational seminars held in conjunction with the show. For Syntopican XIV, which AISP is sponsoring for June of next year in San Francisco, Donio says the association will "integrate some educational seminars onto the exhibit floor." Donio adds "The entire approach [to trade shows] needs a shot of electricity." *–Larry Waller*

SEMICUSTOM CIRCUITS

ZYMOS STRUTS ITS STUFF WITH PC ON A CHIP

Sunnyvale, Calif.

A steep market downturn such as the current one could knock the breath out of Zymos Corp., a five-year-old maker of standard cells that has yet to turn a profitable quarter. A truly dramatic demonstration of its capabilities could give it an edge in its make-or-break sales effort.

Zymos, which invested heavily in fabrication facilities to support 2-μm CMOS process technology during the past year, was looking for a good way to show potential customers what the jump from 10,000-gate standard-cell parts to the 25,000-gate chips made possible by the new process could mean to them. The company's solution was to integrate the contents of the IBM Corp. Personal Computer AT motherboard—less the 286 processor and memory—on a single chip called Poach, short for PC on a chip.

The Poach circuit actually left out another integrated circuit besides the 286, random-access memory, and read-only

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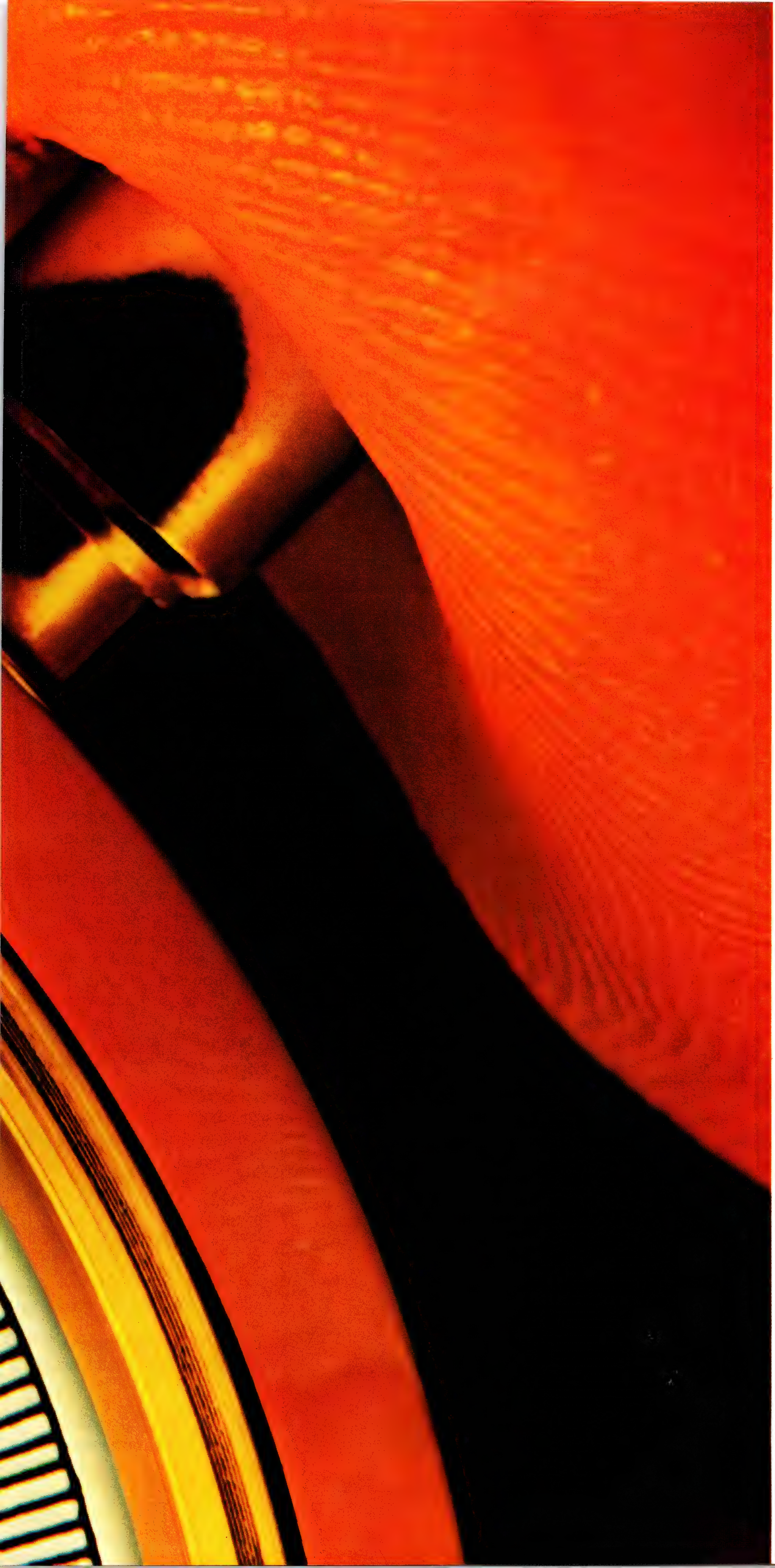

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memory: an 8042 universal peripheral interface. But the Poach design implemented the board's 87 other ICs, eight of which are large-scale parts. Poach measures 450 mils on a side, has a gate count of 21,443, a cell count of 11,642, and 230 bonding pads.

Zymos calls Poach a silicon template, meaning the design can be customized. "A sensible approach for an AT-compatible maker would be to omit some unnecessary features," according to Alex Young, the firm's senior vice president of engineering. Young says such a reduction could reduce the chip's dimensions to the 350-by-350-mil range, a size that allows Zymos to achieve good yields.

At that size, the chips (less the package) would sell for about $50 each in volume. Standard cells have taken a back seat to gate arrays in cost mainly because they have lagged gate arrays by one generation in process technology, points out Dave Guzeman, marketing vice president for Zymos. With the 2-μm process, however, Zymos can undercut gate array prices, reaching levels of 0.2¢ to 0.3¢ per gate, he explains.

Yank the belt. The company's gross profit levels have leapt into the positive column during the first two quarters of its 1985 fiscal year, but net profits haven't been recorded yet. Choosing not to go through several stages of belt-tightening during this year's soft market, Zymos executives gave a single firm yank: at the end of April, the firm laid off about 38% of its work force, mostly in production.

The PC AT chip carries 21,443 gates and 230 bonding pads

So Young claims the lightened Zymos can survive indefinitely on a $10 million line of credit it has only recently touched. The $40 million raised when the company went public in July 1983 is gone. Excess capacity resulting from the investment in production equipment and the market downturn has led Zymos to offer foundry services. Foundry work will contribute significantly to its revenue base within the next six months, the company says.

But the primary thrust at Zymos is standard-cell technology, and Young points out that the margins for application-specific ICs remain far more attractive than they are in the commodity-chip business. He says standard-cell design activity has remained fairly steady despite market conditions.

Zymos claims the largest cell library available, which with the introduction of the 2-μm cells now totals over 1,000 cells. The 2-μm library contains 330 digital cells, with nearly that many at the 3- and 5-μm levels; the 5-μm library also includes 100 analog cells. The Zyp design-automation system also has compilers for RAM, ROM, and programmable logic arrays, and cells can be wrapped around core microprocessors. An 80C49 processor is available now, and an 80C51 is expected next year.

The new 2-μm process, which Zymos calls CHMOS3, uses n wells and two layers of metal. Because of the diffusion effects, transistors are fabricated with effective channel lengths of 1.3 to 1.5 μm, and the gains in performance are every bit as impressive as the density that the process achieves. Nominal gate delays of 700 ps are typical, making possible flip-flop toggle frequencies of 50 MHz and system clock rates of 35 MHz, says Young.

To obtain these speeds, polysilicon is used for transistor gates only, never for interconnect paths, where its inherent resistivity would induce delays. Contacts connect the polysilicon gate structures, which lie atop oxide layers only 250 Å thick, to the second metal layer.

Zymos also announced this week that it is offering its entire library of standard cells to users of Daisy Systems work stations for a refundable $1,500. A designer with a Daisy, after creating the schematic and a simulation model for his chip, invokes a program that automatically extracts the netlist used by the Zyp system at Zymos.

Customers can choose other tools to generate a netlist, which can then be entered into the Zyp system from a terminal at the customer site. Zymos says that thanks to its efforts to make the Zyp system easy to use, customers have designed 87% of the chips it has produced so far. *–Jeremy Young*

COMPANIES

FIRING, LAWSUIT CHECK DATAPOINT REBOUND

San Antonio, Texas

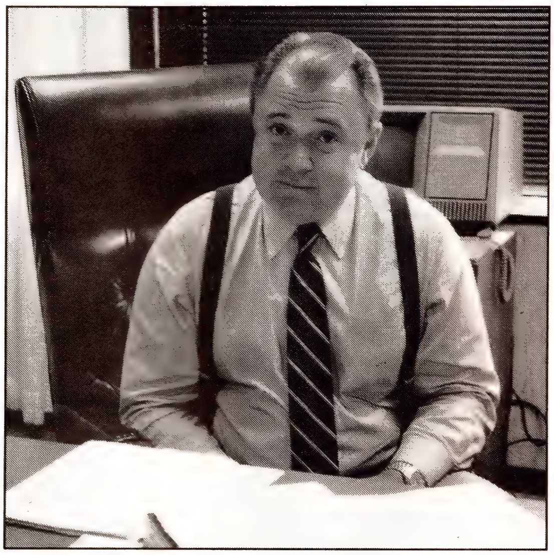
June was a month that most officials at Datapoint Corp. would like to forget. Even though the slide in orders stopped and the firm's cost-cutting measures proved even more successful than expected, the month that most had hoped would mark a rebound at the Texas computer maker was marred by a high-level firing and the filing of a federal lawsuit.

The suit claimed that John C. Butler, Datapoint's ousted chief operating officer, had secretly collaborated on a takeover attempt. For many industry analysts and former employees, the episode exemplifies Datapoint's troubles in recent years.

"Once again, corporate bungling has dampened the chance for a brighter future," complains a recently departed Datapoint technology manager who requests anonymity.

Many executives still with Datapoint believe the firm's demise began three years ago when it uncovered questionable bookkeeping practices that overstated computer sales. Net earnings in 1982 tumbled to an eight-year low. After a slight rebound, Datapoint's outlook was dimmed again six months ago when new leadership promised investors that it would sell off assets. That worried Datapoint's customer base. Weeks later, the company assured them that the plan had been dropped, and the firm would stay intact.

The most recent round of bad news began in early June when Butler, chief operating officer for only four weeks, was suddenly fired for objecting to a planned spinoff of the firm's customer service division into a separate public company. The next week, Butler, previously a 25-year veteran of Sperry Corp., went public with his objections by releasing copies of a letter to Datapoint's board of directors. The board



Under fire. Fired four weeks after he was hired as chief operating officer, John C. Butler now faces a Datapoint lawsuit.

then proceeded to approve the spinoff.

In mid-June, Datapoint filed the suit against Butler, claiming the 52-year-old executive had been secretly helping an acquisition attempt by Dallas businessman Sam Wyly, the chairman of both Netamerica Corp. and Sterling Software Inc. Wyly was meeting with Datapoint chairman Asher B. Edelman just as the controversy began to unfold, according to court documents filed in Philadelphia.

Datapoint claims it discovered the plot after Wyly told Edelman that he objected to the service division spinoff. The acquisition talks reportedly then fell through. The suit charges that Butler passed on confidential information to Wyly and was promised a post as chief executive officer in Datapoint if Wyly acquired control. Both Edelman and Wyly decline to discuss the matter. Datapoint further charges that Butler's persistent objections to the service division spinoff were not based on the merits of the plan but rather on Wyly's own objections.

Damage suit. The suit asks for more than $10,000 in damages from Butler and an injunction barring the former official from divulging or using confidential information. Butler, who had not yet moved his household to Texas, was unavailable for comment from his home in Blue Bell, Pa.

Six months ago, Edelman led stockholders in a takeover battle aimed at selling off pieces of the slumping computer maker. The plan was later revised to keep Datapoint intact, spinning off only the service division as a separate company. Today, the arbitrager-turned-chairman says the firm is not up for sale but interested buyers will "certainly not be thrown out the door.

The suit charges Butler secretly tried to aid a takeover

"We have stabilized our order rates. . . . We are very pleased with where that is, and we have cut out $65 million from our budget now," he reports from his New York office. In late May, Datapoint reported it had reduced its operating costs by an annualized $56 million compared with an earlier set goal of $40 million. The firm continues to operate with losses, however, reporting a $28 million deficit in the last fiscal quarter.

Edelman thinks the worst has passed. "We have pretty much finished our cuts and we are now working on increasing our orders. The company feels it has done what most others in the industry have not yet done, and that's to bring down expenses to meet the lower revenue base." *–J. Robert Lineback*

NEWS BRIEFS

AT&T REACHES OUT TO IBM COMPUTERS

Continuing its attack on the computer marketplace, AT&T Co.'s Computer Systems Division brought out a host of new products last week, including software packages with which users of its 3B line of minicomputers can communicate with mainframe computers made by IBM Corp. The four "host connectivity" packages, the company says, are "a major step forward by AT&T toward total integration of discrete computer systems into networks."

The company also introduced two new members of its 3B product line—the 3B2/400, a supermicrocomputer that can handle 25 users, and the 3B15, a superminicomputer that supports up to 60 users. Prices for the 3B/400 range from $19,950 to $34,950; the 3B15 sells for $54,400 to $64,500. AT&T also cut prices by 20% on its 3B2/300 computer. In addition, it unveiled a variety of software applications programs.

SIEMENS LAUNCHES COLLEGE PROGRAMS

In an effort to help West Germany achieve technological parity with other countries, Siemens AG, the country's biggest producer of electronic components, has embarked on an ambitious program that aims at close cooperation with the country's universities in various fields of electronics technology. To do this, the Munich firm has earmarked nearly $35 million for university investments over the next three to five years. An equal amount will be put up by the universities.

Of the $35 million slated for the program, Siemens has set aside about $7 million over the next three years for work in microelectronics (especially custom very large-scale integrated circuits). Another $9 million will be spent over the next five years for a factory-automation project involving computer-aided-design and -manufacturing systems; $12.5 million will be spent over three years in an office-equipment project; and a number of smaller communications-related endeavors each will get about $2 million.

MOSTEK PARENT TAKES OVER PLANT

Mostek Corp.'s Colorado Springs plant for 64-K random-access memories, which was closed in May, is being converted by the chip maker's parent to make semicustom circuits for military and aerospace markets. United Technologies Microelectronics Center, headquartered near the empty Mostek fabrication facility, plans to move its operations into the vacant building soon, giving UTMC full wafer-production capability.

Earlier this year, the center entered the military and aerospace chip markets after having been serving only the internal needs of United Technologies Corp. subsidiaries. The fab line is being equipped for both MOS and bipolar technologies. It is expected to produce both linear and digital application-specific integrated circuits. UTMC officials estimate that the move into wafer production will increase the center's workforce by 75 people. It now employs 250.

FRENCH READY TRANSLATION SYSTEM

A prototype system that translates text written in French into nearly faultless English will be demonstrated this September by five French organizations working under the aegis of a national computer-aided-translation (CAT) project. Currently limited to translating French aeronautical texts into English, the system is being developed into a concrete product. An additional thrust is aimed at extending its capability to other fields and additional languages.

Under development since 1983 and administered and funded by the French Agence National de l'Informatique, the French CAT project is being executed by a multidisciplinary team of more than 25 researchers consisting of computer and software engineers, linguists, and translators. Lead responsibility for the project is being assumed by Société Générale de Gestion. Other partners are the GETA (a French acronym for Automatic Translation Research Group), the Institut de Formation et de Conseil en Informatique, Sonovision SA, and Traductor SA.

RAYTHEON WINS MILSTAR CONTRACT

Raytheon Co. last week won a $256 million contract to design terminals for the U.S. Air Force's extremely high-frequency satellite communications system, known as Milstar. The Lexington, Mass., company will now serve as prime contractor on a team, which includes Rockwell International Corp., that is scheduled to design and build two dozen of the terminals by June 1990. The contract award may give Raytheon an edge in capturing additional Milstar program contracts from the Air Force and other military services—business that may eventually total billions of dollars. Raytheon beat out a team led by Hughes Aircraft Co. to win the contract for the terminals.

DUAL OPERATING SYSTEMS: A COMPROMISE IN QUEST FOR A STANDARD

by Larry Waller

COMBINATION OF TWO SYSTEMS IN ONE MICROCOMPUTER COULD WIN ON ITS ECONOMIC MERITS

Which microcomputer operating system will become the industry standard? After nearly a decade of jousting among interested parties, the answer may come from the forces of the marketplace. The system that makes economic sense, say sources from all quarters, combines several software standards in a single computer. A dual operating system is what they have in mind.

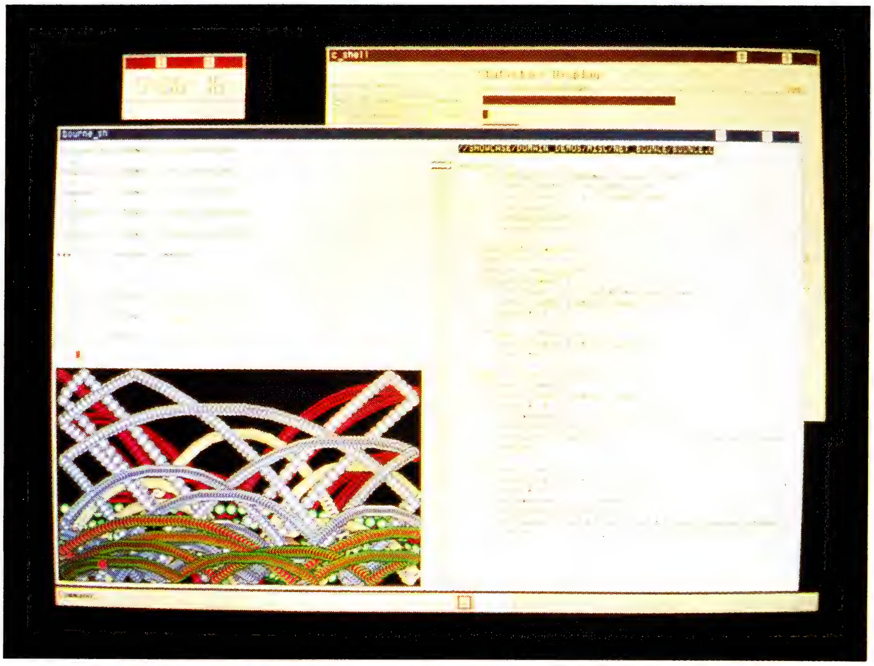
The first wave of dual operating systems consists of mix-and-match versions of the two leading standards: MS- or PC-DOS and Unix. For now, these arrive primarily as plug-in optional boards (and some as software, but this is on the wane) with which an original-equipment manufacturer or value-added system integrator can add a second processor, making the system compatible with both camps. As usual, it is the more sophisticated segment of the microcomputer business that leads the way.

Combining Unix. More than just these two out-front microcomputer-based standards are involved. Higher up the performance ladder, at the superminicomputer level where Unix already dominates, developments are also moving apace. Three firms already provide hardware that combines the two Unix programs: System V, from AT&T Bell Laboratories, and the popular Unix enhancement, 4.2BSD, from the University of California at Berkeley. Industry scuttlebutt has it that other companies will soon join in with similar versions.

The timing of this melding process comes as little surprise to consultant Bryan Boyle, of San Francisco's Novon Research Group. "It's a natural outgrowth of the standard operating systems reaching a phase where they are sufficiently defined for this." He calls what is happening now "sex-change operations" that are part of a bigger picture of hierarchical ferment, linking large minicomputers and mainframes without elaborate and expensive conversion software and gear.

Purists may insist, correctly, that coprocessing, dual-processor-support, or coexistence operations are nothing new. Dating back to the beginnings of microcomputers, they mostly worked through dual processing: a second processor added to a microcomputer supported a second operating system. For more powerful machines, two systems often were supported through software or firmware, running on the same engine. Though a few solutions were somewhat successful, the concept didn't catch on enough to spark a widespread trend, sources say.

One dual-processing microcomputer that has been well received is the Z-100 from Zenith Data Systems, introduced in mid-1982. It is equipped with both an Intel 8085 and 8088 for handling 8-bit CP/M and 16-bit DOS-based software, respectively. "We're still selling tons of them, and we've got absolutely no intention of taking the Z-100 out of our product line for a long time to come," says a representative.



Opens windows. Users of Apollo's Domain/IX software can simultaneously run Berkeley 4.2 and System V Unix systems on separate windows on a Domain work station.

With the move to dual operating systems just beginning, no reliable estimates of market size yet exist, according to Boyle. But engineering work stations top the list for potential upgrades, both in improved versions on the drawing boards and in those 13,000 already installed. The reasons center not only on practicality—it is easier to graft DOS onto a machine powerful enough to run Unix than it is to force Unix into a low-end microcomputer—but also on the well-known demand of these users for more performance.

As in the early phases of any hot trend in the volatile computer business, each month brings new products from firms looking to tie into it. Many sources, in fact, pinpoint late January's UniForum '85 and its numerous product announcements as the signal that an authoritative move toward dual operating systems was building.

Few observers at that time, however, tied them together; this understanding

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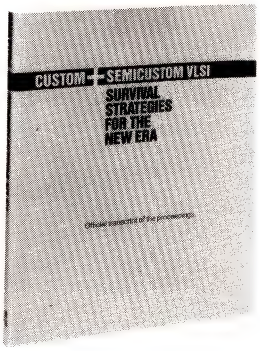

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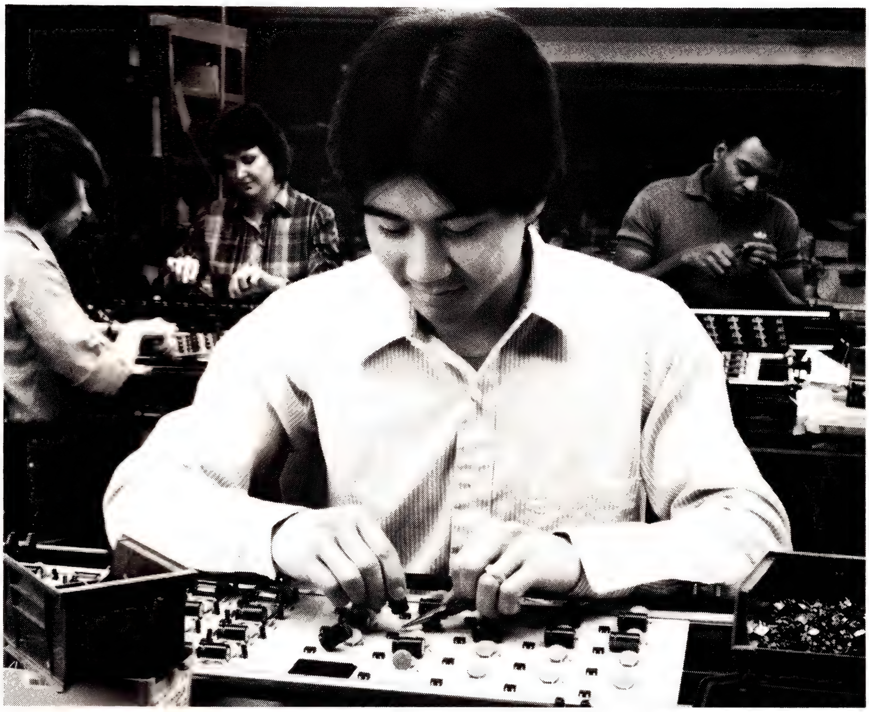

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lagged by several months.

Among the companies that launched entries then, Opus Systems clearly stated its intention with the Opus516 Personal Mainframe. The 1984 startup says the Unix/coprocessor subsystem converts an IBM Corp. Personal Computer to a 32-bit work station. It is based on the National Semiconductor Corp. 32-bit 32016 processor and allows an easy, one-keystroke transfer between Unix System V and DOS-based software.

President and cofounder Jon Lundell agrees with Novon Research's Boyle about the timing of such gear. "With the wide acceptance of Unix as a standard operating system and the PC as a standard productivity tool, it made sense to combine them to create a high-performance system at a reasonable price." In quantity, the Opus unit in a 1-megabyte configuration sells for $3,140. With the product, users running software on larger computers can bring it to the desktop level with no trouble, he adds.

Sritek Inc. offers coprocessor boards for both 32- and 16-bit worlds. One of these plug-in cards for IBM microsystems carries a National 32016 and runs Genix 4.1BSD (National's version of Unix); another product carries a 68000 running Unix System V. The 32016 card, with 2 megabytes of memory, a 32082 memory-management unit, a 32081 floating-point chip, and Genix, costs $3,995 and "outperforms the IBM PC/XT and PC AT and equals the [Digital Equipment Corp.] VAX," says a Sritek representative.

The Sritek boards were introduced in 1982 and 1983. At Uniforum, the Cleveland firm showed them with a modification that lets them work in PC ATs, plus a feature that allows the user to switch back and forth from Unix to applications running concurrently under DOS.

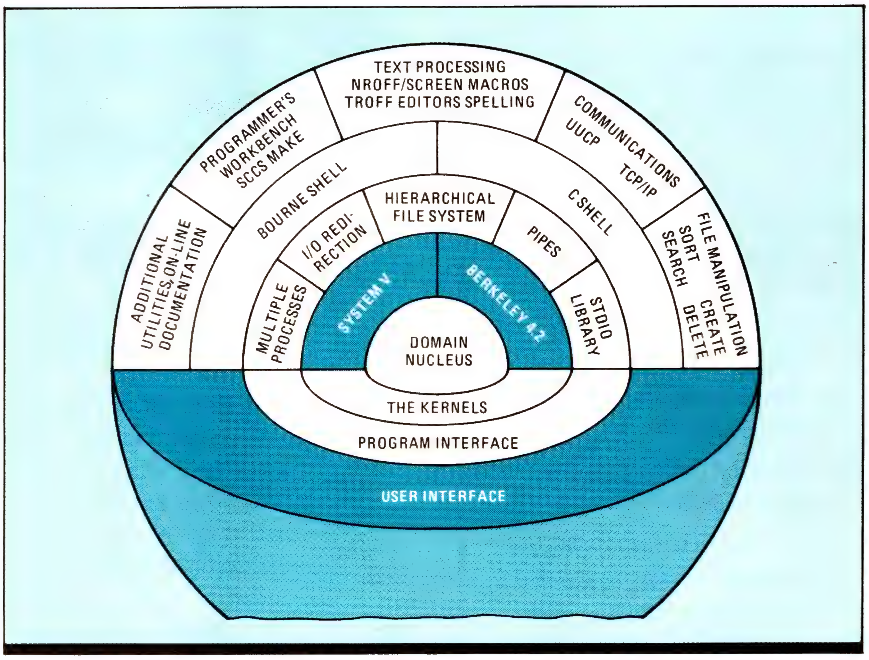
On the DOS side. Approaching the issue from the DOS side, Phoenix Software Associates Ltd. takes its first venture into hardware with a coprocessor compatibility package that uses the Intel 80286. It brings IBM compatibility to various machines running Unix, including the 68000, 16016/32032, and the Western Electric 32000. With it, DOS may operate cooperatively with Unix in a file-sharing mode that is transparent to the user, according to Lance E. Hansche, executive vice president.

The firm, previously a supplier of IBM-compatible software for OEMs, entered the hardware fray in May, behind the others. Hansche says his company's product was in hand for nearly 18 months as fallout from software development, "but we sat on it while going on to other things."

What changed his mind was a new OEM salesman who, in beating the bushes for business, described a possible coprocessor to producers of work stations. "He called 43 [firms], and 42 wanted to talk right away," Hansche recalls. Providing DOS tools to the Unix environment "might get us all rich eventually, but it certainly wasn't apparent to me before then." The firm expects the price of its units to drop from the current $2,395 tab to $1,895 by fall, as volume grows.

To the uninitiated, combining System V and Berkeley 4.2 might seem an unnecessary refinement—each system claims to be the one that satisfies users' needs. But all observers agree that it is the user who has dictated the marriage, because each has strong points not duplicated by the other.

Berkeley 4.2 is said to be the technologically more advanced of the two. It has unique functions that make it popular with software professionals. But System V, with the support of Bell Labs, leads as a development tool and has more commercial users. Surprisingly, however, the two systems are impossible for users to integrate, points out Mark J. Hatch, product manager at Apollo Computer Inc. "Unix compatibility is a myth."



Two for one. By integrating Unix 4.2BSD and System V into a distributed-processing environment, Domain/IX provides network-wide transparent program and data sharing.

After comparing over 300 unique user commands offered by both versions, Hatch says Apollo found that only 50 are completely compatible. "A hybrid system that mixes and matches features would not maximize portability of programs and user skills."

Rolled out in May, Apollo's Domain/IX software for its 32-bit Domain work station permits a user to choose either version of Unix at any time or run both simultaneously. Furthermore, the co-resident operating system is designed for a distributed network, at a price of $425 per node and $9,100 for up to a 100-node site.

Who's on first? Pyramid Technology Corp. and Gould Inc.'s Computer Systems Division support Hatch's reasoning on the demand for combining the two systems. But each points out that it beat Apollo to it by more than a year.

Pyramid shipped its first OSx dual-port operating system for the 90x superminicomputer in February 1984. "Pyramid early recognized that the reality of the matter is [that] we have to support both systems to be a viable force," says Ross A. Bott, manager of the OSx group for the Mountain View, Calif., firm. But he adds that the OSx internally is a Berkeley 4.2 system, which he considers superior because of its ability to handle demand-page programs and fast file systems. Bott estimates that more than 70% of Unix users have 4.2.

Similarly, Gould says its UTX/32 starts from a 4.2 base and adds System V features. "We're riding both horses, giving the best of both to the customer," says Gregory L. Hopwood, director of Unix marketing support.

Looking to the future, consultant Boyle thinks the marketplace will sort out competitive claims as standards continue to evolve. Still to be heard from is Bell Labs, which many expect to play a role in further Unix developments. Also, with this trend barely under way, players are already looking to the next development. Gould's Hopwood thinks this might be the emergence of distributed file systems with different operating systems. ☐

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Online Computers Plus
PAX Computer Center
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Inacomp Computer Centers
MicroAge Computer Stores
Sears Business Systems Centers
Spectrum Computers
Valcom Computer Center
Minnesota
Amerisource
Blumberg Photo & Sound
Computer Applications Business Center
Computer Depot
ComputerLand
The Data File
Entré Computer Centers
MicroAge Computer Stores
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ComputerLand
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WILL 'SMART HOUSE' PROVIDE SHELTER FOR HIGH-TECH FIRMS?

by George Leopold

18 ELECTRONICS COMPANIES PARTICIPATE IN DEVELOPMENT AS NATIONAL ASSOCIATION OF HOME BUILDERS WORKS ON SPECS

Washington

Proponents of the "smart-house" concept, a unified power-and-signal wiring system designed to replace the venerable system of 120-V ac electrical circuits, describe it as "an idea whose time has come." By 1987, says the National Association of Home Builders (NAHB), it will be promoting and selling the smart-house system for installation in the 1.5 million homes built annually in the U.S.

Whether that projection is realistic remains difficult to determine. But so far, the NABH has persuaded 18 companies to join Smart House Development Venture Inc. and plunk down the $15,000 necessary to get in on the ground floor. (Firms joining at any later stage will have to pay substantially higher fees, the NAHB says.)

To attract members, the association has agreed to limit the number of players, thereby providing members with what it hopes will be a competitive edge in the home-automation and -management market. Negotiations to add another 15 firms are also underway, says Pieter A. VanderWerf, assistant director of the NAHB Research Foundation in Rockville, Md.

Among current members are a handful of home-computer makers and other electronics firms—including Apple Computer, Commodore, General Electric, and Honeywell—who hope the smart-house idea will provide new markets for their products amid the current slump [*ElectronicsWeek,* May 27, 1985, p. 40]. "It sort of holds something for everybody in consumer electronics," says Jack Francis, a systems engineer with General Electric Co.'s Consumer Electronics Business Operations, Portsmouth, Va., a key player in the U.S. home-control market.

Building support. The concept has also garnered considerable support from within the 130,000-member NAHB, which, according to VanderWerf, includes approximately 85% of the nation's residential and light-frame home builders. "This is something our membership wants," he asserts.

In addition, the NAHB Research Foundation is working with the Commerce Department's Office of Productivity, Technology, and Innovation to obtain private-sector financing—it needs to raise approximately $50 million for research and development costs. It is also working with the Energy Department's Oak Ridge National Laboratory to develop a comprehensive plan to integrate home appliances, entertainment devices, energy management, security systems, and so on.

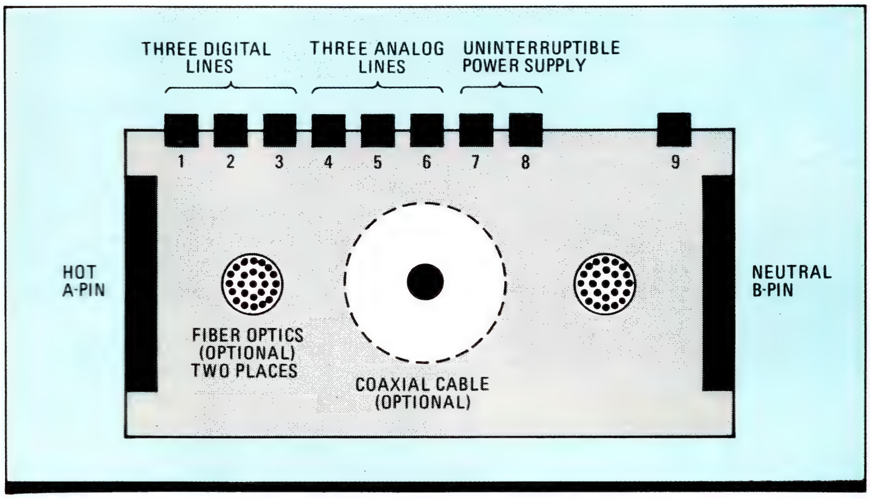
The goal of smart-house advocates is a set of compatible products, including:

- An integrated power-and-signal bus tying all electrical devices in the home into a single power and communications network.
- Central controllers to regulate current and information flow throughout the network.
- A telephone interface so that information and instructions can be passed to and from the network directly over telephone lines.

The two primary features of smart-house technology are the closed-loop and programmable-power concepts. Under the closed-loop system envisioned by the NAHB, appliances and other home devices would generate a signal to tell a system controller—a microprocessor currently under development by Smart House Development Venture and others—which devices need power. The system controller would then send power through the circuit to the appropriate device.

One plug fits all. In addition to the closed-loop signal that identifies the device and its operating status, the controller will also receive signals telling it what kind of power the device requires. This programmable power feature determines, for example, whether a device requires 120 V ac at 5 A or 50 V dc at 3 A. Further, home appliances, monitoring systems, and signal distribution would be integrated into a single plug, thereby reducing the redundancy of current electrical systems.

At the same time, VanderWerf says, the NAHB Research Foundation will seek the necessary changes in the National Electrical Code to allow installation of the system in new homes. "If the National Electrical Code is modified [to include smart houses], then consumer acceptance becomes a secondary issue," asserts



Plugged in. The smart-house wiring scheme would integrate electricity, telephones, security, and fire detection while distributing audio, video, and data throughout the home.

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Bob Edwards, a member of the Smart House Advisory Committee who works out of the Oak Ridge National Laboratory, Oak Ridge, Tenn.

Working on net. Meanwhile, attention has turned to developing system specifications and, in particular, a standard network for home control. Along with the NAHB, the Electronic Industries Association, the Washington-based industry trade group, is also seeking a standard network [*ElectronicsWeek,* Jan. 21, 1985, p. 18].

The EIA's Consumer Electronics Bus Committee, made up of about 50 firms, is working on a voluntary standard of its own while monitoring the progress of the smart-house project. Thomas D. Mock, the committee's staff engineer, says the fundamental difference between the proposed standards is that EIA's doesn't require a system controller.

Builders are not too concerned about the system's initial cost

Mock thinks the whole notion of home automation will not necessarily lead to new uses for personal computers but rather to new features that will make them easier to use. For example, computer peripherals wouldn't have to be located in the same room. "That would make a computer more attractive," he argues.

GE has been pushing hard for a standard since the introduction of its signaling protocol, Homenet, two years ago. Homenet has not yet been sold as a product, explains GE's Francis, but he says the Fairfield, Conn., company may have to begin marketing it if there is no action on a standard soon. Francis has been working closely with the NAHB, but he adds that GE is not sure whether the NAHB's closed-loop and programmable-power concepts are necessary for a standard network.

Joanne Volakakis, manager for home control at GE's Consumer Electronics Business Operations, indicates that the lack of a network standard may also be slowing the development of power-handling chips needed for the network. "We have been in sort of a quandary until we find out what the standard is."

Nevertheless, GE's Power Electronics semiconductor department, in Syracuse, N.Y., has developed and produced "smart power" chips that are capable of withstanding 220 V ac. Tom Daly, the department's product manager, views the smart-house project in terms of new applications and concludes, "I think there is very large potential here."

Another chip maker looking to put elements of a communications network on silicon is National Semiconductor Corp. Peter Hillen, the Santa Clara, Calif., company's strategic marketing manager for home information systems, says that the firm has been active in smart-house technology since the initial meeting last December and that it is close to officially signing on, once licensing issues are resolved. One reason, Hillen says, is because the Japanese are concentrating on home automation as the next big consumer electronics market.

Home builders who have contacted the NAHB about the smart house are generally favorable about the concept. "It's a house that's going to be easier to wire," notes Ken McDermott, a contractor in Pottersville, N.J. McDermott, who says he builds between 8 and 10 custom homes a year, sees "more home-oriented activities" and says prospective customers have been asking for smart-house features. Further, McDermott explains that the NAHB is providing a focus manufacturers of individual systems could not. "Now I think there's going to be some cooperation."

Approves. NAHB's Pieter A. Vanderwerf says that industry supports the smart house.

"If you have technology coming onstream, a person would be a fool not to take advantage of it," concurs Mike Galluzo, a home builder in Norman, Okla. However, Galluzo says he would probably first build a prototype home for himself before selling to his customers.

Both builders say they are not too concerned about the initial expense of the new wiring system. The NAHB estimates that it now costs about $3,500 to install an electrical system providing power, two telephones, and, perhaps, cable TV to one room. Observes Volakakis of GE: "I think the question is not whether it's going to happen, but when." ☐

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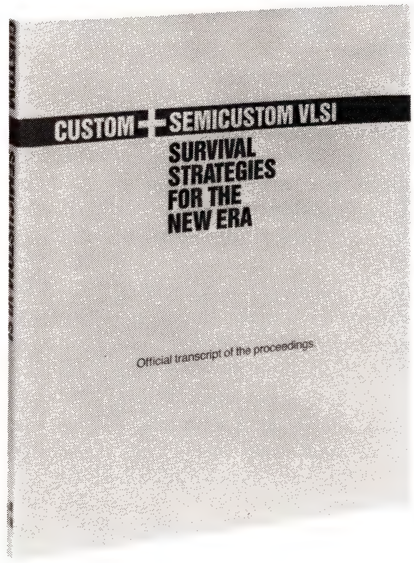
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DRAWN BY MIT, HIGH-TECH FIRMS CONVERGE ON CAMBRIDGE

by Craig D. Rose

KENDALL SQUARE IS NOW KNOWN BETTER FOR HIGH TECH THAN FOR THE SMELL OF SOAP

Cambridge, Mass.

There is a saying that the three basic rules of real estate are location, location, and location. In the rapidly developing Kendall Square area, location is spelled MIT—everybody wants to be near the Massachusetts Institute of Technology.

The dozens of electronics and related firms located here have made the area a booming commercial technology center that is likely to attract many more companies. In recent years, developers have built more than 700,000 ft^2 around Kendall and plan an additional 800,000 ft^2, along with 600,000 ft^2 slated for rehabilitation. In June, construction began on a 400-room Marriott hotel, alongside a large pedestrian plaza also under construction. Even the ancient subway station is being renovated and expanded. Prompting all this activity is the desire of electronics companies to be within a floppy disk's throw of MIT.

This was not always the case for the Kendall Square and East Cambridge areas, just across the Charles River from Boston. Though MIT has long served as an incubator of ideas for industry and new companies have sought to be within easy reach of the school, growth and success for such ventures in the past usually meant high-tailing it out to the cheap commercial space along routes 128 or 495 in the Boston suburbs.

Until the late 1950s, the Kendall Square-East Cambridge area was still defined by a declining array of older industrial enterprises such as chemical companies and a large soap factory. "You knew you were in the Kendall Square area when you came out of the subway by the smell," recalls Thad Tercyak, deputy director of the Cambridge Redevelopment Authority.

No soap. It was the closing of the soap factory that prompted the city to approach the school for help in redeveloping the area, adds O.R. Simha, MIT's director of planning. In response, Simha says that MIT served as the principal catalyst and provided financial support for the construction of Technology Square, which started in 1960 on a parcel just west of the more recent Cambridge Center development, home of Polaroid Corp. and others.

Also in 1960, the National Aeronautics and Space Administration proposed building a research center in the Kendall Square area. The city believed the NASA facility could serve as the backbone for a major renewal project and planned accordingly. But those plans were short-lived. After constructing one 16-story building and four low-rises, NASA announced in 1969 that it was pulling out of Cambridge.

Local politicians scrambled and managed to get a Department of Transportation facility to partly fill the void left by NASA. For the rest of the area, Tercyak says the city considered everything from luxury housing to open space.

Hot spot. The Kendall Square-East Cambridge area has become a real-estate hot spot for electronics firms. At right is the MIT campus.

Eventually, the city made plans for mixed-use development—offices, light industry, and commercial use—and more than \$50 million in federal funding was secured. Private development, including the hotel under construction, totals over \$100 million and may eventually approach \$300 million. Despite the overwhelming presence of electronics and high-technology companies, the objective was not to build just a high-tech center.

What the city hopes the project will do is increase the number of jobs and improve their quality, along with increasing tax revenues, says Tercyak. At the same time, the city wants to avoid creating an area that turns into an urban desert at the conclusion of the workday. Instead, "It could be MIT's Harvard Square," Tercyak says, referring to the busy neighborhood adjacent to Harvard University that is crowded with bookstores, boutiques, and trendy restaurants.

David Barrett, senior vice president of Boston Properties, says that the developers had hoped the project would profit also from its proximity to Boston's financial district and government center. But he says, "Not many tenants have moved across the river from Boston—the Charles is wider and deeper than we thought."

Barrett can afford to view the issue philosophically because all his available space is rented, thanks in large part to electronics and software tenants. But for the high-tech tenants, nearness to Boston has also become an issue.

At Symbolics Inc., for example, there were fears that the East Cambridge location would put the company at a recruiting disadvantage, says Abraham Hirsch, senior marketing manager. The company tended to recruit people from Route 128 companies, and many of those people faced hour-long commutes.

Steppin' out. The location turned out to be a lure. "A lot of people like being here because they tend to be young and do things downtown afterwards. They can be downtown in five minutes by subways [or] be in Harvard Square in five minutes," says Hirsch. Customers, many of whom visit for training on the Lisp computers, have also enjoyed being close to downtown Boston and to the airport, he adds.

Symbolics is typical of the companies that have located in the area. It first rented a small space with a storefront on a nearby street. Later, it took additional storefronts, then a single floor, and finally a year ago moved into its own 80,000-ft^2 building. Earlier plans called for subleasing some of that space, but Symbolics found it quickly made use of the space itself.

Hirsch says the company wanted a data link to MIT, which has some 60 Symbolics machines. "This allows people who have ties to MIT to walk across the street," says Hirsch. "People visit both ways and do a lot of business."

Charles Stark Draper Laboratory Inc. was among the first of the recent wave of high-tech companies to try the Kendall area. Draper, spun off from MIT in 1973, was dispersed in many buildings throughout the area. When it built its new headquarters, it chose Technology Square.

"We wanted to stay near MIT because it is an important part of the atmosphere and culture," explains Joseph O'Connor, the lab's vice president for administration.

Another long-time area tenant is Computer Corporation of America, founded in Kendall Square in 1965. President James Rothnie says the company was first located in a "facility that was sort of a motel for companies—30-day leases." Though it later added space in other parts of the city, in 1983 it came back to Kendall and consolidated in Cambridge Center.

"We think this particular area promises to be a key technology center," Rothnie says. "The location casts an image that we think is an accurate reflection of this company. We expect it to become a prestige area."

Much of East Cambridge is undergoing a similar transformation. Lotus Development Corp. moved its headquarters from the Central Square area of Cambridge to a spot nearer the Charles River and Boston. Janet Axelrod, a vice president, says the location is excellent for building a work force with varied backgrounds, which is a company objective. Large manufacturing operations might confront limitations of space in the Cambridge area, she adds, but this will not likely be a major issue for Lotus, which now employs 800 and has much more room to grow.

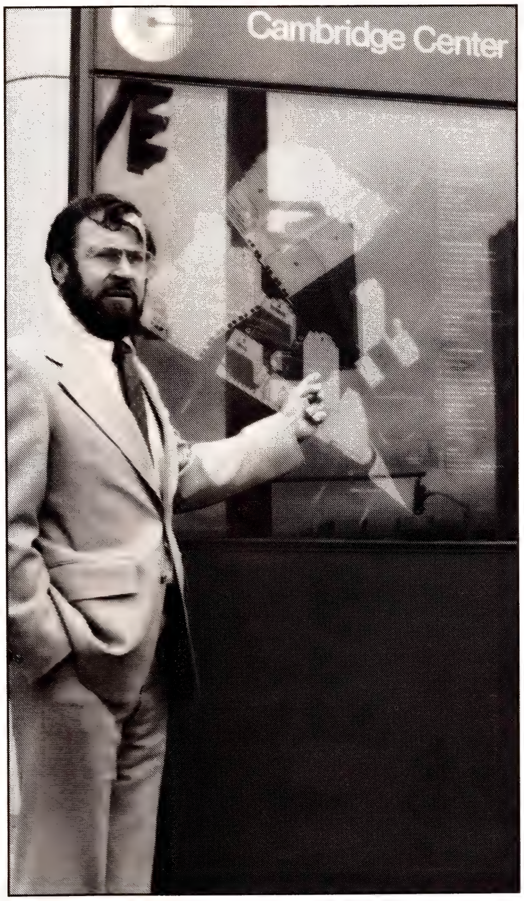
Ripple effect. But though companies may locate in the city to attract a diverse work force, the ripple effect of the high-tech commercial development has been the gentrification of a working-class city. Citizens' groups have made proposals for so-called linkage and inclusionary zoning. These would require builders to contribute to a fund for low-income housing, or in the case of residential development, to provide units for lower-income tenants.

"Obviously, the developers didn't want to do it," says Joseph Kellogg, Cambridge's director of economic development. He adds that MIT and Harvard also opposed the measure, which has for the moment been withdrawn.

Meanwhile, the extension of the subway system to the city line, where it meets a major commuter highway, has spurred development in the Alewife section of Cambridge, farther away from Boston. This area is also experiencing rapid growth and has its own high-technology base, with Arthur D. Little Inc. and Bolt Beranek & Newman Inc. as long-time residents.

Overall, firms will find more than 1 million ft^2 of additional space available by next year. This comes on top of 3.5 million ft^2 built since 1980. Commercial rents in Kendall Square are still \$25 to \$30 per square foot. Given the current slump in the electronics industry, however, developers are becoming concerned about the ability to rent the space that will soon be available. Kellogg says the vacancy rate has jumped from about 8% to between 12% and 14%.

But Barrett reckons that rising and falling with the electronics industry comes with the territory. "The one aspect of being in the real estate business in Cambridge is that you're also in the venture capital business," he says. *–Craig D. Rose*



High hopes. Thad Tercyak of the Cambridge Redevelopment Authority, hopes Cambridge Center becomes "MIT's Harvard Square."

PLAYERS

KODAK REFOCUSES TO PUT OFFICES IN THE PICTURE

Integrating acquisitions with its traditional businesses, the photography giant shifts to high technology

Rochester, N.Y.

My work," George Eastman wrote in his 1932 suicide note, "is done."

Eastman, the heirless founder of Eastman Kodak Co., built one of America's biggest business empires, a $10 billion conglomerate focused on the photography business, but also reaching beyond cameras, film, and paper, to chemistry and plastics. For years, the company reigned almost unchallenged.

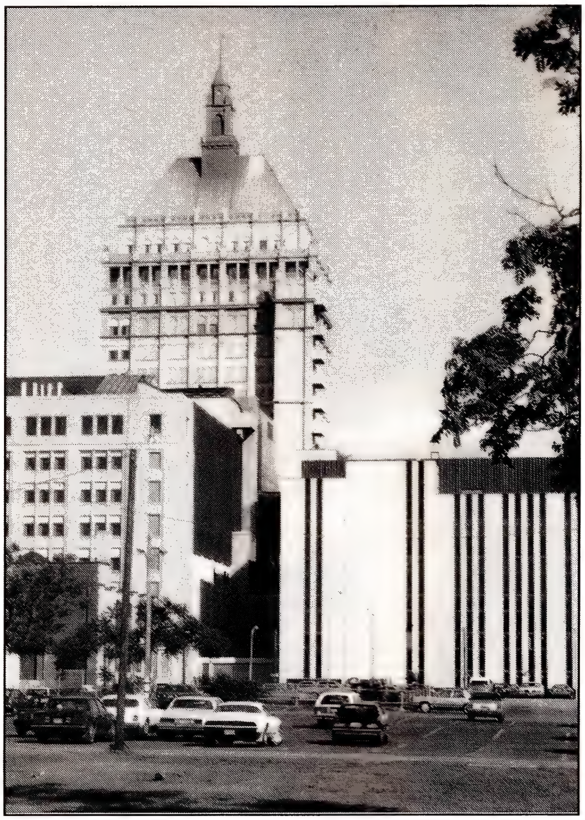
Now, a half century later, Kodak is trying to forge a presence in a different kind of business—office equipment. It is mounting a challenge to its biggest competitor and one-time Rochester neighbor, Xerox Corp.

Shifting focus. Last fall, when the company changed the name of its Photographic Division to the Photographic and Information Management Division, it was doing more than just realigning operations. It was sending out a message: Kodak, the company that put photography into nearly every American home, was shifting its focus to high technology and preparing for a major push into the U.S. office.

In this way, the firm hopes to revive its sagging business performance. Following a 6% drop in sales in 1983 (to $10.2 billion), sales in 1984 rose a scant 4% to $10.6 billion.

"In the years after World War II, [Kodak] had the entire photography market to themselves," says Philip Cavalier, a financial analyst at Pershing & Co., New York. "They enjoyed a great growth rate," with the development of color film and simpler cameras. However, Cavalier continues, "there's been nothing revolutionary in photography in years," and for a large organization like Kodak, exploring new avenues for growth was an absolute must.

A decade ago, Kodak stepped timidly into the office-copier market. Since then, Kodak's position there has grown so that it now enjoys a comfortable spot in the copier market's high end. A recent agreement with Canon Inc. of Japan to market a midrange copier under the Kodak label should expand the company's base in that market even more. Unveiled with relatively little fanfare, the product shows how Kodak is squeezing into the highly competitive office arena.



Shifting focus. Eastman Kodak hopes high technology will revive its sales.

Kodak's philosophy is to merge its own technological strengths with those of other vendors and use the easily recognizable Kodak nameplate as a launching pad to the marketplace. "Marketing and financial strengths are as important as technology," says Cavalier in discussing the Kodak strategy.

Adds John Gell, Kodak's manager of electronic markets in its Copy Products Division: "We looked at the market and saw there were many companies that offered parts of the process—one of the steps—but none integrated a whole system. We went out and took the best of what we found and integrated them [under the Kodak name]."

Kodak did more than purchase parts for its systems. It bought companies and parts of companies as well. The first major acquisition was Atex Inc., an electronic publishing systems company, in 1981. Other purchases include Diconix (formerly Mead Digital Systems), in 1983, a maker of high-speed ink-jet printers, Eikonix Corp., a producer of digital scanners and image-processing systems, and Verbatim Corp., the floppy-disk manufacturer. In addition, Kodak invested $20 million last October in Sun Microsystems Inc. and $5.1 million in Interleaf Inc., a software developer.

Having woven each of these firms into its own vast empire, Kodak took aim at its copier competitor, Xerox. In May, it unveiled a pair of systems it hopes will establish it as a major force in the information-systems market: KIMS (Kodak image-management system) and Keeps (Kodak Ektaprint electronic publishing system).

Designed for use in document-intensive operations, KIMS consists of a robotic film autoloader, four charged-coupled-device scanners, and a family of graphics work stations that are connected to a Digital Equipment Corp. VAX computer. The autoloader can hold up to 240 Ektamite film magazines (equal to 3.5 million pages of paper documents). Each system can include up to six autoloaders. Thus a system has a potential data base of over 20 million pages of documentation.

Users can access documents in seconds, then compare and view up to four pages at once using the work station's windows. They can enlarge a segment of the image for closer inspection by up to four times and, without making changes directly in the file, amend it as a clerk might by "paper-clipping" a note to the file.

Scheduled for fourth-quarter release, Keeps will accept text from a variety of word processors. It can process graphics, merge text and line art, add headlines and headings in various fonts, and produce print of near photo-typeset quality. The result is a presentable document for in-house or limited-circulation distribution, produced almost instantly and much cheaper than sending the pages out to a publishing house, according to Gell.

Both typify Kodak's integration of technology from outside vendors as well as from its own divisions, subsidiaries, and partial holdings. Each seeks to set a new performance level in its own niche.

Marketing strategy. "The philosophy of the company is that we want to get the biggest bang, the best performance, and the best reliability we can," says John Clifford, director of Kodak Electronic Imaging Systems in the Business Systems Markets group, the sectors responsible for KIMS. That philoso-

EASTMAN KODAK TIES DIVERSE COMPANIES TOGETHER

Company	Product	Year acquired	Amount
Verbatim Corp.	Floppy disks	1985	$175 million
Eikonix Corp.	Image-processing systems	1985	$56.3 million
Diconix (formerly Mead Digital Systems)	Ink-jet printers	1983	Not disclosed
Datatape	Analog and digital tape recorders	1983	Not disclosed
Atex Inc.	Electronic publishing systems	1981	$81.7 million
Spin Physics Inc.	Recording heads	1972	Not disclosed

SOURCE: EASTMAN KODAK CO.

phy shows in a marketing strategy that amounts to Kodak telling its customers, "We'll give you whatever you need to use our system."

Eugene Glazer, a research analyst at Dean Witter Reynolds Inc., New York, says Kodak's reputation is the key to its ability to go head to head with Xerox with a system of products made mostly outside its own factories.

Following IBM. Kodak says it is prepared to provide a full turnkey office-automation system with the Keeps publishing network, complete with electronic mail, word processing, publishing, copying, and printing, says Gell. That approach, Glazer suggests, puts Kodak on a path similar to the one followed by IBM: it is not on the leading edge of every technology, perhaps, but it supports the full product line.

"They've got an excellent reputation based on very, very strong support for the customer," Glazer says. He explained that although Kodak says it is shooting for the middle ground in office publishing (an area it claims Xerox has left wide open), the two companies are competing for the same market. "The reputation Kodak has in copiers among customers is far better—dramatically higher—than Xerox," he continues. "That's quite extraordinary, given the experience Xerox has in that market—and I think that reputation is transferrable [to office publishing]."

Not everyone shares Glazer's positive view. Cavalier thinks Kodak is entering the new market too late and with insufficient technology to back it up. "There are a lot of different approaches to going into competitive markets. One is to jump in and gamble. A second is to let the market define itself and then carve out a niche for yourself.

"That's what Kodak is trying to do. But I think they're a little late. Xerox has done a better job and Kodak is entering too gingerly, too cutesy-pie. They had to do it. They couldn't wait, because they had to stay close to Xerox."

Kodak went far for the gear to develop the systems. For Keeps, Sun provided the graphics work stations, text controller, and disk-expansion pedestals, Interleaf wrote the composition and workstation publishing-system software, and Canon manufactured the printer.

Vision. Kodak integrated the best of what it found, says manager John Gell.

Four other firms are supplying technology for the systems, and Kodak will offer other, faster printers for the system as its Diconix unit develops them.

For KIMS, Kodak needed more outside help. Without powerful computing technology, the system couldn't handle the density of information with which it is burdened, rendering it nearly useless. So Kodak enlisted DEC's help. In what Clifford calls "something more than an OEM relationship, maybe 'OEM-plus,'" Kodak guarantees that it will know what DEC is doing and planning for the next two to four years.

The alliance between the two is symbiotic, since Kodak gains from DEC's computer skills and DEC benefits from higher sales caused by demand in an as yet untapped market, Clifford says. Says Paul Artlip, director of KIMS marketing: "We're taking the best of Kodak—images—and the best of DEC—their architecture—and we are putting them together" in a way that no one has done before. *–Tobias S. Naegele*

BOTTOM LINES

R&D DOUBLED FROM 1977 TO 1982

Expenditures by U.S. electronics and information-technology companies for research and development more than doubled in the five years from 1977 to 1982, according to a study by the American Electronics Association. Analyzing data from the National Science Foundation, the AEA found that R&D spending rose to $14.4 billion in 1982 from the $6.5 billion spent in 1977. Of this amount, company-financed R&D expenditures in the U.S. electronics industry totaled $10.8 billion in 1982, up 130% over the $4.7 billion in similar funding in 1977. Federally financed R&D spending for the U.S. electronics industry in 1982 totaled $3.6 billion, just double the $1.8 billion of federally sponsored work five years earlier.

W.R. GRACE ACQUIRES CHOMERICS FOR STOCK

Chemical giant W.R. Grace & Co., New York, has acquired Chomerics Inc., Woburn, Mass., for 2.4 million shares of Grace common stock. Chomerics, with 1984 sales of $45.8 million, develops and markets materials and components for electronic packaging to companies in various segments of the electronics business.

CONTINENTAL TO BUY IPC COMMUNICATIONS

Continental Telecom Inc., a vendor of telecommunications and information-processing services in Atlanta, has agreed in principle to acquire IPC Communications Inc., Greenwich, Conn., for approximately $55 million. IPC, which designs and makes telecommunications equipment used primarily by brokerage firms, banks, and securities and commodities companies, had revenues of $70 million in fiscal 1984. "We are impressed with the quality of the IPC products and the profitability record of the business," says Continental Telecom president John Lemasters, in explaining the proposed acquisition.

TESTER STARTUP RAISES $5.25 MILLION

Support Technologies Inc., Tigard, Ore., has raised $5.25 million in its second round of venture financing. This follows the $2.25 million that the company raised in July 1984. The new funds will be used to further develop the company's product, a low-cost automated tester aimed at servicers of electronic equipment.

ISRAELI DOES TAKEOFF ON SILICON VALLEY

Herzlia, Israel

The scenario is familiar. A bright design engineer working for a major electronics manufacturer has a hot idea for a product. He makes a pitch to management but gets nowhere. So the bright engineer goes off and starts his own company.

Shift. Clarity president Amos Wilnai went from design engineer to entrepreneur.

This stereotypical Silicon Valley scenario is still new to Israel, a land known more for its biblical heritage and survival instinct than for entrepreneurship. But it is occasionally played out.

Amos Wilnai, for example, left National Semiconductor Corp. and in 1983 returned home to found Clarity Ltd., a developer of computer-integrated-engineering systems and custom very large-scale-integration design services. In May, Herzlia-based Clarity in turn gave birth to Clarity Systems Inc., a Sunnyvale, Calif., marketing arm.

Wilnai's idea has resulted in Clarity's Superset 5000 computer-aided-design and -engineering system targeted for full-custom VLSI design (see p. 60). To get feedback on design concepts being developed, Wilnai added an Integrated Circuit Design Group, and Clarity just announced a $900,000 deal with Signetics to design a CMOS chip.

Lifeline. Clarity is very much the persona of Wilnai, a native-born Israeli who was educated in the U.S. and worked for American companies. The firm straddles the old world and the new, balancing on two complementary facts: an Israeli company cannot exist without a strong presence in the U.S., and U.S. companies have a high regard for Israeli research engineers.

Wilnai is such an engineer. With a master's degree in electrical engineering from Brooklyn Polytechnic and nine years cutting his professional eyeteeth with Corning, Signetics, and Monolithic Memories, Wilnai "just went where I felt best," and returned to Israel. As a design engineer with U.S. firms there, he designed the 2101, 2111, and 2112 chips for Intel Corp. and, at National Semiconductor, headed the group that designed the 32000 family.

Although Wilmai takes credit only for "putting the right team together and giving them the tools," he recognizes the increasing difficulty of designing complex chips efficiently. "It took 50 man-years to design the 32016, the basic microprocessor, and three years later they are still finding bugs. When you start to think about the next generation of chips, you can't design them with the tools we have now."

So Wilnai and David Askenazi, the project's software manager and now Clarity's vice president of research and development, tried to convince National to develop a CAD system that would enable the design of complex chips with fewer errors and less effort. When National showed no interest, the two formed Clarity. They raised money within Israel because Wilnai couldn't convince U.S. venture capitalists to wait two and a half years for any return. "We needed at least that long just to develop an infrastructure."

A design engineer by background and temperament, Wilnai had reached a stage in his career where he had to choose between staying at the design board or moving into management. "If you want to accomplish more, to do better, you have to use other people," he says. "Even if you don't want to give up your former life, you have to. It's a compromise." *–Jesse J. Leaf*

ANSLOW'S ORDERS: RAISE U.S. SALES

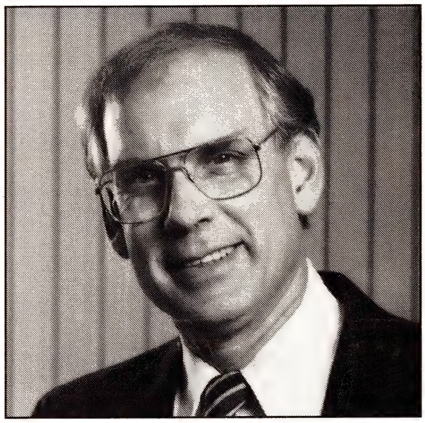
Irvine, Calif.

Taking over a semiconductor company in the face of what may be the stiffest industry downturn yet is a tough task. Making it tougher for Robert E. Anslow, who took over as general manager at Plessey Solid State last month, is the fact that his bosses expect him to grab a bigger part of the fiercely competitive U.S. market.

Expanding market share is a daunting task for any firm these days, but it seems positively Herculean for the tiny Plessey operation, formed in 1977. Its sales, though not broken out by British parent The Plessey Co. plc, were probably under $10 million last year.

Despite this small working base, Anslow is optimistic. What gives Plessey a competitive advantage, he says, is solid technology support from the parent. "The research at Plessey's Caswell [England] Center is top-notch, better than I've seen at any other merchant-market manufacturer."

Anslow, 52, has more than 25 years of experience in semiconductors, most recently at Rockwell International Corp.'s Semiconductor Products Division, where he was director of strategic planning. Rockwell associates in nearby Newport Beach praise Anslow, who holds a chemical engineering degree from Massachusetts Institute of Technology and an MBA from Harvard University. "He's an outstanding guy with classic credentials and was quite successful," observes Charles V. Kovac, vice president for major accounts.



Parental support. Plessey Solid State general manager Robert E. Anslow is counting on solid support from parent The Plessey Co.

In line with his intent of "moving out and making ourselves better known," Anslow plans to beef up component distribution and the sales network. In keeping with guidelines from Plessey officials, however, Anslow says the U.S. Solid State unit will stay closely linked with multinational operations.

Product push. Already in his company's product line, and destined to be pushed for wider U.S. sales, are high-speed bipolar parts that run at 2 GHz. Work is continuing on CMOS, too, scaling the process down to 2-μm geometries and focusing on circuits to run at speeds of 40 to 50 MHz. CMOS gate arrays also are at the center of Plessey's semicustom products, one of the fastest-growing U.S. businesses. A design center in Irvine serves customers, and improved CAD equipment is in the works. Other activities include design engineering for hybrid devices, which are fabricated in England.

Anslow calls the semiconductor slump "the most sudden and rapid I've ever seen. The roller coaster started down last year and hasn't really gone back up much." *–Larry Waller*

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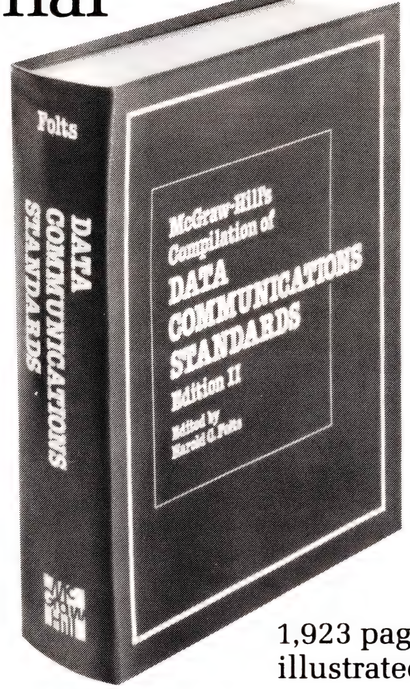
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THE PELL-MELL RUSH INTO EXPERT SYSTEMS FORCES INTEGRATION ISSUE

by *Tom Manuel*

SOFTWARE-DEVELOPMENT TOOLS FOR NON-AI-TRAINED USERS MOVE EXPERT SYSTEMS INTO EVERYDAY APPLICATIONS

Expert systems, once an esoteric research curiosity, are emerging from artificial-intelligence research to find practical applications in the real world. Corporations, government agencies, and the military are rushing to exploit this unique type of computer software—programs that capture and encode the knowledge of skilled people and experts for use by less-skilled technicians or the experts themselves. Yet there is a lot of confusion about how best to harness the technology's benefits and tap its potential for widespread commercial use. Many organizations either know or think they should get into expert systems but are not sure where to start.

Most expert systems up to now have been stand-alone, experimental systems. But nearly everyone who is familiar with them believes that to be truly useful, most expert systems will be integrated with existing computer applications. This integration is becoming a key issue. It means that expert systems should be able to hand off results to other programs and accept information from them or even go out and search external data bases for additional information. For example, expert circuit-design aids will be most effective if they are an integral part of complete design-automation systems.

Basic expert systems consist of two vital elements: a knowledge base and an inference mechanism or engine. Knowledge bases contain specific information about a subject—facts, figures, characteristics, rules of thumb, and conditions. Inference engines, on the other hand, are programs that consult the knowledge base to arrive at advice, a recommendation, or a suggested solution to a problem.

More advanced expert systems are likely to have a knowledge-acquisition subsystem to help the expert, or a knowledge engineer and expert working together, create, modify, and maintain the knowledge base. Expert systems should also contain an explanation facility that tells the end user what knowledge, rules, and line of reasoning lead to a given conclusion or why the system is asking the user a particular question. A complete and integrated expert system will consist of all four parts plus interfaces to many other functions of the computerized system of which it is a part (Fig. 1).

The past year has seen the emergence of serious software tools for the development of expert systems to aid a host of ordinary, everyday problems, and many useful systems have been built, with hundreds more in progress. These systems cover a broad range of applications; expert systems are running now in the fields of computer-aided circuit design, integrated-circuit production, oil exploration, and process control, as well as configuring computer systems for manufacturing, medical diagnosis, finance, and marketing (see table, p. 57).

It is likely that nearly every major U.S. corporation has or is initiating an AI group to start building—or at least start looking at—expert systems. Also, the Department of Defense and the National Aeronautics and Space Administration are interested in expert systems for battlefield missions, strategic-defense computer systems, space shuttle missions, and the upcoming space station. Expert systems and AI in general are a big part of the Defense Advanced Research Projects Agency's Strategic Computer Initiative.

Expert-system activity is not limited to the U.S., either. Much work in expert-system technology is going on in Western Europe and Japan. But before expert systems achieve widespread acceptance as a simple way to solve problems, as most software veterans predict they will, some glaring needs must be filled. Topping the list, even the staunchest proponents admit, is the need for commercial software development tools that can be put to work by people who are not AI specialists. But prospects for easy-to-use AI tools are improving rapidly. Two recent meetings devoted to AI and expert systems—one in the U.S. and the other in France—brought to light many new expert-system development products. At AI '85, a first-time national show held in early May in Long Beach, Calif., many of the approximately 35 AI hardware and software firms exhibiting products introduced new expert-system software-development tools, several of them running on personal computers instead of the more expensive machines built especially for AI.

And at the Fifth International Workshop on Expert Systems and Their Applications also held in May in Avignon, France, more than half of the technical program was devoted to expert-system development. At the accompanying exhibition, no fewer than 30 of the 49 participants were displaying expert-system tools, shells, and inference engines. Offerings ran the gamut from a $200 expert-system builder for Apple Computer Inc.'s Macintosh to highly sophisticated $50,000 software packages for that special breed of AI hardware known as Lisp machines. Approximately 20 of these software packages are of European origin and have such fanciful names as KOOL, TESS, Tigre-1, Criquet, and Golem.

Expert systems to dominate AI software

"The key to AI's success will be the value added by AI software whether that software is a stand-alone application or, especially, when AI is used to enrich many ordinary applications," says Kenneth R. Sonenclar, program director of the Gartner Group Inc.'s Industry Service. Most of the software with AI technology—about 90%—for the next five years will be expert systems or expert-system related, according to Sonenclar. Gartner Group analysts believe, as do quite a few other computer industry people, that AI applications or applications with AI content will have to either run on IBM Corp.'s hardware or be able to coexist closely with it, especially in office applications and in integrated applications within the largest companies. In dollar volume, the sales of AI software will begin to rise sharply by 1987 (Fig. 2).

Some large companies have well-established AI departments and have already built some prototype expert systems. But for many organizations, expert-system skill is an unfamiliar technology they deem important enough to learn about. The newness of the field is reflected in the questions being asked: for example, what tools and techniques are available now, and how much can they do? Organizations want to know if people not highly trained in AI can build usable expert systems with these tools. Some think not. The people who are offering so-called easy-to-use expert-system development tools naturally say yes. But, on the other hand, if skilled expert-system practitioners are needed, how can they be found or trained?

A polarization of opinion seems to be developing around these questions regarding expert systems: on one side are those who maintain that meaningful systems still require the specialized Lisp-language machines, people with AI programming skill and experience, and maybe one of the big, comprehensive development tools. On the other side are those who believe that useful systems can be developed now by people not experienced in AI by using personal computers or work stations and the expert-system shells and development tools currently available. What can be done today really depends on what the user wants to do and the resources he will apply.

Personal computers and work stations with the concomitant tools can be used, at the very least, to learn about expert-system technology and get some basic experience. In some cases, they can be used to develop and deliver usable, though limited, applications. However, most companies currently building expert systems that are more than prototypes maintain that efficient Lisp machines and the very rich development environment that comes with them are essential.

Although the number of new software tools that surfaced at the Long Beach AI gathering indicates stepped-up efforts in the field, some observers still remain unimpressed with their quality. Harvey P. Newquist III, editor of "AI Trends," an industry newsletter in Scottsdale, Ariz., thinks this crop "doesn't show much improvement over those already available." He says current software tools represent "simply the quickest way to get something to market." Too many of them are still language-based and require a user to start from scratch; they do not relieve much of the preliminary programming burden.

But Newquist sees better tools ahead, perhaps appearing as soon as the Ninth International Joint Conference on AI, which will be held in Los Angeles Aug. 18-24. He thinks some important firms are targeting products for this show, which is expected to be the biggest yet for AI. Industry reports hint that minicomputer makers Digital Equipment Corp. and Data General Corp. are planning major AI splashes there.

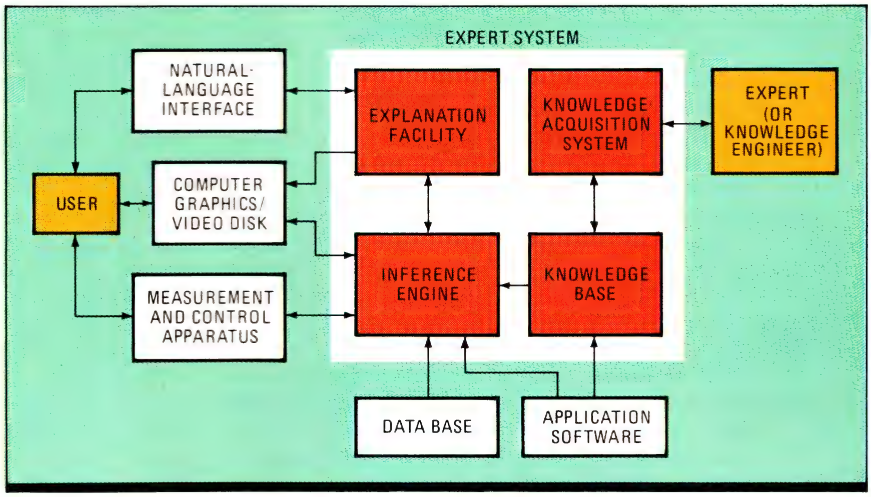
There was also considerable debate at the Avignon workshop about the utility of the current crop of tools for the would-be expert-system creator with a limited background in AI. "My own feeling is that [selling expert-system development tools to nonspecialists] is a bit premature," says Jean-Michel Truong-Ngoc, founder snd president of Cognitech SA, a Paris company that specializes in developing expert systems.

With a French government contract to produce 30 expert systems for farming applications [*ElectronicsWeek*, May 27, 1985, p. 25], Cognitech has developed Tigre-1, its own set of tools designed to facilitate the construction of diagnostic expert systems. But even Truong-Ngoc is skeptical of how easy it would be for a neophyte to shop the market for the proper tools to create his own expert systems. "Just choosing the tools that are best suited to deal with specific kinds of applications is specialist's work," he explains.

The opposite opinion is held by James Chapman, executive vice president of Human Edge Software Corp. Chapman thinks this budding industry does not need technology hoarders who try to keep the know-how in the hands of a few specialists. "Expert-systems technology can and should be used to solve everyday problems," says Chapman.

Human Edge Software is currently offering two personal computer-based expert-system building tools—Expert Ease and Expert Edge—that do not require the user to be an AI expert. The company is also delivering several of its own expert-system applications for business strategy and personal development.

In addition, Human Edge will publish a catalog of third-party run-only expert systems built with its development tools. With the expert-system capability Human Edge and


EXPERT SYSTEM
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USER
COMPUTER GRAPHICS/VIDEO DISK
MEASUREMENT AND CONTROL APPARATUS
EXPLANATION FACILITY
KNOWLEDGE ACQUISITION SYSTEM
EXPERT (OR KNOWLEDGE ENGINEER)
INFERENCE ENGINE
KNOWLEDGE BASE
DATA BASE
APPLICATION SOFTWARE

1. Not an island. The typical expert system—consisting of a knowledge base, inference engine, knowledge-acquisition subsystem, and explanation facility—will not be isolated from other programs and data bases in the computer system where it resides.

several other companies are offering to personal computer users, Chapman asks, "why shouldn't people have access to the technology?"

The ways to develop expert systems today can be grouped into three to five categories, depending on who one talks to. However, there is general agreement about the first two approaches.

One road to building expert systems is to train current workers in AI techniques or try to find and hire experienced people. The next step is to start building something using one or more of the AI programming languages such as Lisp, Prolog, and Smalltalk, and, if using Lisp machines, the rich development support environment available.

A variation of this approach is first to develop an in-house expert-system development tool using the AI programming languages—some corporate AI groups have even done this using conventional programming languages. One company to take this approach and develop its own expert-systems tool technology is Hewlett-Packard Co. (see "HP builds a base in AI technology," below). As a computer maker, HP felt it had to own, control, and master its own software technology. Equally important to HP was to have expert-systems technology on its own general-purpose computers and have it interface or be integrated with the traditional software tools on those systems.

In contrast to a computer company's approach to expert-systems technology, Litton Industries Inc., a large, diverse industrial company, takes advantage of commercially available systems. Litton's method is an example of the second basic way to develop expert systems, that is, to buy and use one or more of the commercial multifaceted expert-system development tool products (at this time mainly available on the AI machines or bigger general-purpose computers such as superminicomputers and mainframes), bring in consultants when necessary, and train in-house people in the systems' methodologies.

Among the big commercially available expert-systems development packages that offer powerful knowledge-representation languages and a variety of inference mechanisms, there are three systems that are leading the pack. All currently require Lisp machines or a minicomputer the size of a DEC VAX. The first out of the starting gate (in August 1983) and perhaps the most mature with a second version under its belt, is the KEE (for Knowledge Engineering Environment) system from Intellicorp, Menlo Park, Calif. The other two are ART (Automated Reasoning Tool) from Inference Corp., Los Angeles, and Knowledge Craft, just released by Carnegie Group Inc., Pittsburgh.

Commercial pioneer

When introduced, KEE was the first large, comprehensive expert-system development tool kit to be marketed commercially. The installed base of KEE is now growing quickly. According to Thomas P. Kehler, executive vice president, there are now approximately 200 KEE systems installed for about 60 customers. "The many repeat sales to the same customer—several companies have 10 installations—is an indication of product success," says Kehler.

This object-oriented system is directed at two kinds of users. First, it is well suited to a developer and customizer of expert systems to be used much like a high-level programming language. Like programming languages, KEE can also be used by knowledgeable end users.

KEE has an open architecture around its object-oriented system core, and functions can be added to the tool kit. Intellicorp plans to extend KEE in three ways, says Kehler. First, the company will build problem-solving environments for specific types of problems using KEE as the foundation. In

HP BUILDS A BASE IN AI TECHNOLOGY

Hewlett-Packard Co., a computer maker that chose to get into artificial intelligence and expert systems by building its own technological base, kept a group at its central research lab working in secret for four years. The research group at Hewlett-Packard Laboratories, Palo Alto—a force of approximately 50 people under the direction of Ira Goldstein—is currently polishing up the core AI technology that it developed more or less from scratch. This technology can be thought of as a large tool box that includes a knowledge-representation language, object-oriented and rule-based knowledge-engineering tools, and a rich application-development environment. One of HP's goals was to build a strong AI technology that would fit into its computer architectures.

The AI tool box contains compatible tools from both the AI world and the general software environment. HP-RL, the name given the overall AI tool-kit system, is in most respects like Intellicorp's KEE system, says Steven Rosenberg, department manager for expert systems. However, HP's goals were different: "HP is not concerned about appealing to the first-time users but instead building a system with enough underlying strength and power for a broad range of applications," says Rosenberg.

On the road toward such large systems, HP has developed several in-house applications as tests and demonstrations of its AI technology. Among these is the Photolithography Advisor, an expert-system program for integrated-circuit manufacturing. The program has captured the knowledge of HP's best IC process engineers for use by process-line technicians to help diagnose problems in the lithography steps by aiding them in visual inspection. The program can help diagnose problems and recommend solutions in most cases without the need to call in a process engineer. The biggest advantage of rapid diagnosis is higher yields—a high-payoff result.

The Photolithography Advisor expert system has been under development and in use for three years. It is now used in a production line in Santa Clara, Calif. Terry Cline, project manager at HP's Expert Systems Division, says the program is very good, though not perfect: "It's equivalent to having a process engineer on the line, although not quite as good a one as [our] senior process engineer."

The expert system collects information from the process technician by cleverly asking questions about visual faults on the wafers. HP is improving the Photolithography Advisor with an optical-disk drive that will be able to display photomicrographs of wafer faults and ask, in effect, "Does it look like this? Or this?"

HP's approach to expert-systems and AI technology has worked extremely well. But for a consumer rather than a vendor, the HP people suggest it might be better to buy solutions to problems or buy tools, training, and consulting for expert-system development. Some companies will want to develop some expert-system tools themselves.

HP is still working on a number of other AI applications, including a system for the interpretation of infrared and mass-spectrometer information in chemical research; fault diagnosis in hardware, software, and networks; and some work on an expert adviser in very large-scale integration design and layout.

EXPERT SYSTEMS TAKE ON A VARIETY OF ADVISORY JOBS – A SAMPLER

System	Manufacturer	Application
XCON/XSEL	Digital Equipment Corp.	Configures computer systems for customers and manufacturing
Lithography Advisor	Hewlett-Packard Co.	Helps process technician to diagnose IC wafer-fabrication production problems
Alarm Advisor	Lisp Machine Inc. and Texaco Inc.	Alarm monitor for automated oil refinery; alerts and advises operators
Promoter	Management Decision Systems Inc.	Assistant for planning and controlling sales promotions
Mudman	NL Baroid/ NL Industries Inc.	Oil-well drilling-fluid diagnostic and treatment consultant
MORE	Persoft Inc.	Direct-mail marketing expert adviser
DAS	Carnegie Group Inc.	Family of VLSI design aids for signal analysis, logic design, layout, and design process management.
EPA Water-Permit Review System	Software Architecture and Engineering Inc.	Aid for issuing and reviewing water-discharge permits from the Environmental Protection Agency

particular, the company will be doing this for Darpa under a recently announced two-year, $1 million contract. Darpa and Intellicorp will work together to specify the extensions the agency needs. Here, KEE will be extended to deal with a diversity of knowledge types, different types of knowledge constraints, experiential rules of judgment, structural descriptions, and mathematical simulation. One of the goals will be to bring all types of knowledge together into one system.

Second, KEE will be made more usable for a larger group of users. And third, it will be made more efficient for delivery vehicles other than Lisp machines. This is becoming a key issue in transferring AI technology into the commercial world. In Kehler's words, "A major development [we can expect to see] within the next year is the movement of AI technology onto traditional architectures."

State of the ART

The ART system from Inference is in the same class as KEE—an expert-system development tool kit with multiple knowledge-representation and inference paradigms. It was a little later entering the market, but it is gaining a following rather quickly. There are now roughly 30 customer companies using about 50 copies of ART. "Almost none of the customers have backgrounds in AI," says Chuck Williams, vice president of technology. Although ART has extensive on-line help and an abundance of documentation to ease the first-time user along, it requires a learning investment to truly master its range of possibilities.

"It is possible to build very complex systems with some training, as our customers have demonstrated," claims Williams. The effective use of ART and other similar systems comes quite quickly (in months, not years) after the vendor conducts training and then helps the customers' programmers build the first system or two.

A good example of a successful ART customer is the NASA Johnson Space Center, where computer scientists and engineers are continuing to create expert systems for the space shuttle and space station programs. NASA is the farthest along of ART customers, having five prototypes in operation and at least as many more under way. The first operational system at the space center is Navex, the expert system that operates the high-speed ground navigation console during space shuttle take-off and landing [*ElectronicsWeek*, Feb. 4, 1985, p. 51].

ART costs between $60,000 and $80,000 and is designed to run on all Lisp machines from Symbolics Inc. and Lisp Machine Inc. as well as on VAX computers equipped with VAX-Lisp. It has four primary components: a knowledge-representation language; a compiler that maps the knowledge into Lisp code and data structures; a run-time applier for solving specific problems; and an environment that allows the developer to control and monitor the system during the development process.

Before any expert system can be useful, an adequate and accurate knowledge base is essential. So the Carnegie Group emphasizes knowledge representation. "If you can't represent knowledge, you can't solve problems," explains Mark Fox, a founder and chief technical officer of Carnegie Group. Therefore, Fox's company first developed an advanced knowledge-representation language, CRL, an enhancement of the SRL schema-representation language developed and proven at Carnegie-Mellon University. CRL is a language that uses schemata—or frames, as they are often called—which group related chunks of knowledge together and define the relationships between them. The Carnegie Group, however, takes the technique several steps further.

Boosting the productivity of higher-level AI computers is the goal of Carnegie Group's Knowledge Craft, an integrated knowledge engineering package. Combining CRL with a variety of problem-solving paradigms, knowledge-based editors, user interfaces, and development utilities, the tool greatly reduces the time required to build expert systems, says Larry Geisel, president of the Pittsburgh firm. It is comprehensive enough for a wide variety of robust applications. It supports object-oriented, logic- and rule-based reasoning mechanisms using a common knowledge base. Other inference strategies can be added easily. Knowledge Craft's price is $50,000, but that includes training and support. It runs on the Symbolics 3600 family of Lisp engines, Texas Instruments Inc.'s Explorer, and DEC's VAX series.

The frame-based structure of CRL allows meta-knowledge, meaning that it encodes not only bare facts but knowlege about those facts. It can also represent user- and system-defined dependencies in the knowledge to make the knowledge base dynamic and adaptive to knowledge changes—an area of knowledge engineering that has been the greatest impediment to the successful implementation of expert systems, according to Fox.

Knowledge Craft also handles user-controlled searches, and can define contexts where different versions of the knowledge base are represented by just the differences between the versions. This allows expert systems to capture knowledge from experts with differing opinions.

Other expert-system development tools especially suited to the AI machines and superminicomputers are the S.1 system from Teknowledge Inc., Palo Alto; OPS5, offered by Digital Equipment Corp., Maynard, Mass. and others; and an OPS5 derivative, OPS83, from Production Systems Technologies Inc., Pittsburgh.

No experience necessary

The first two approaches to building expert systems require at least some people with training, understanding, and skill in AI and expert-system programming techniques. To obtain such people, an organization has two options: recruit and hire them, which is often difficult and expensive these days; or pick some good people and give them some training and get them to build something.

The third approach (or the third, fourth, and fifth, depending on viewpoint) involves expert-system development tools and languages for personal computers and work stations. Here, it is claimed, people without extensive AI training and experience can achieve useful results. It is in this realm where there are some differences of opinion as to whether there is one methodology or several. Some people break this category into two or three subcategories.

There are those who classify all attempts at building expert systems on 8- and 16-bit personal computers and 32-bit work stations in a single category. And some of those people often dismiss the entire category as just playing around.

In subdividing the personal computer category of expert systems and development tools, a couple of steps can be taken. In the first place, the powerful work stations based on full 32-bit microprocessors just appearing can be placed in a separate class from today's standard 16-bit personal computers. These powerhouse 32-bit work stations perform well enough to be considered for quite serious expert systems. Personal computers with such 32-bit horsepower are also expected soon.

A further breakout is possible within the personal computer realm. For example, William Turpin, manager of knowledge systems at TI, talks about two classes of personal computer expert-system development tools. "There are the starter expert-system tools—very low-cost things—for personal computers for people to get their feet wet and find out about [the technology]. Then there are what I would call personal computer production systems that can be used to develop and deliver usable expert-systems on personal computers."

Of course, TI's own Personal Consultant product is placed in this latter category. The Personal Consultant is an expert-system development package based upon the Emycin technology developed at Stanford University, and is now available on the IBM Personal Computer and compatible family of products as well as TI's Professional Computer series.

New options

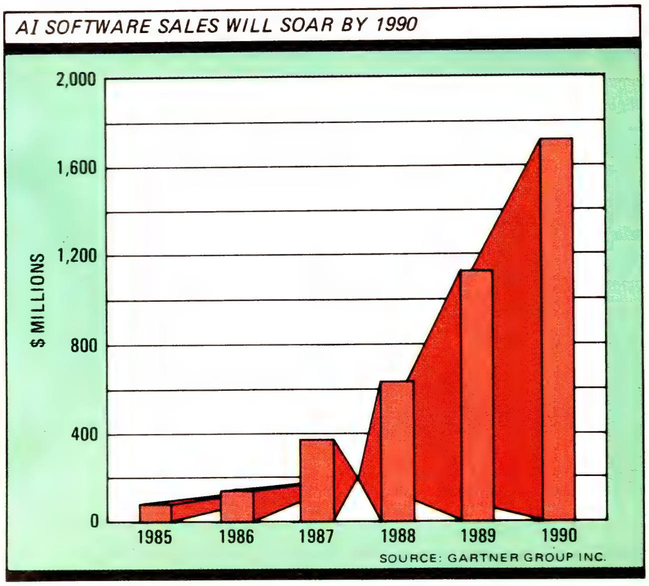
There are advantages as well as disadvantages to every method of building expert systems. Many companies will likely benefit by trying a combination of two or three of these methods. Now many organizations can start seriously thinking about and even get into using AI technology because these options are available. There is no doubt in many people's minds, including Turpin's, that personal computers and the AI software tools available for them is helping bring this about. Regardless of the approach taken, the advice unanimously given by those who have built an expert system or two is to build something. The admonition is to get started.

Assuming an organization gets started developing expert systems, there still remains the question of the kinds of computers that are going to be used to deliver these expert systems to the end users. The costly AI machines may be excellent vehicles for expert-system development, but at current prices of $50,000 and up, companies cannot afford to buy lots of them to spread around as delivery vehicles. However, staunch supporters of these machines firmly believe that prices will drop significantly very soon.

According to the Gartner Group's Sonenclar, the AI hardware business is going to become extremely competitive in the next few years. Lisp machines are going to skid in price down a faster learning curve—35% per year—than traditional computer products (Fig. 3) because of intense competition, VLSI Lisp machine implementations, and PC encroachment. In 1985, $55,000 buys a Lisp machine with two megabytes of main memory, a 140-megabyte disk drive, and a high-resolution monochrome display.

However, the best delivery system in many cases will be something already in place or very affordable, such as personal computers or even terminals to time-shared mainframes and minicomputers. But many expert-system practioners believe that personal computers are not yet powerful enough to run sophisticated expert systems.

Peter L. Gabel, president of Arity Corp., disagrees: "It is absolutely possible to do serious AI on personal computers."


AI SOFTWARE SALES WILL SOAR BY 1990

SOURCE: GARTNER GROUP INC.

2. Software up. Artificial-intelligence software sales, although still separable from conventional software, are expected to rise from very little in 1985 to $1.8 billion by 1990. During this time, expert systems will account for about 90% of all AI software.

And Arity is currently doing just that—developing business productivity software for IBM PCs that incorporates AI technology. "People dramatically underestimate the computational power of personal computers," says Gabel. To develop its products, Arity uses the logic programming language, Prolog, in conjunction with C and assembly language. In fact, Arity's first products are its PC Prolog compiler and interpreter.

"When AI impacts a lot of people it will have an impact on the world," says Denison Bollay, president and chairman of the board of Expertelligence Inc. That impact is going to start to come now from the millions of personal computers out there, he believes. Bolloy's Santa Barbara, Calif., company is offering what it claims is the most complete implementation of Lisp on a microcomputer. At $495, Experlisp for the Apple Macintosh brings development of AI software "within reach of virtually any company or individual," says Bollay.

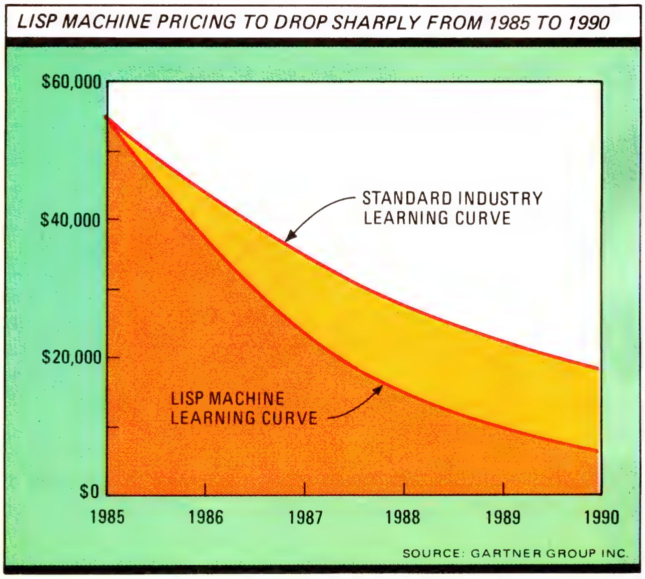
Expertelligence is concentrating on supplying AI software products for the Macintosh. Currently it is also offering Experlogo in addition to Experlisp. This month, Expertelligence will start offering ExperOPS5, a complete version for the Macintosh of the OPS5 expert systems building tool. Later in the year, the company will release its own expert-systems tool that will incorporate both forward and backward chaining, probabilities, and a user-friendly interface.

Bollay strongly believes that some of today's personal computers, and certainly some on the horizon, are capable enough for expert systems. At the Gartner Group forum, Bollay's analysis of how powerful certain personal computers are com-

MICROCOMPUTERS VIE WITH LISP MACHINES

Computer	Relative performance
Symbolics 3600 Lisp Machine	100
68020-based machines (future)	50
68010-based machines, such as Macintosh and Tektronix 4404	10
IBM PC AT and other 286-based machines	10
IBM PC and other 8088-based machines	2

SOURCE: EXPERTELLIGENCE INC.



3. Prices down. Lisp machine prices are expected to drop 35% a year from their current $50,000-plus—much faster than the traditional computer industry learning curve because of intense competition, VLSI implementations, and encroachment by personal computers.

pared to the 3600 AI computer from Symbolics Inc. supported his position (see table, p. 58).

Among the expert-system development tools able to take advantage of advanced personal computers such as a large-memory IBM PC AT, for example, is one called XSYS from a San Francisco-based startup, California Intelligence. According to founder Ray Weinstock, the $995 program brings to the IBM PC world the multiple knowledge representation and manipulation features usually found in the big expert-system development tools.

These features include bidirectional search strategies (both backward and forward chaining), hierarchical knowledge bases rather than a single big one, variables and either system- or user-defined operators in both the If and Then parts of rules, and the ability to give or get results to or from other programs. The system also can search external files and tables for additional information to be used in the reasoning process. Often, expert systems need to communicate with the rest of an integrated computerized system. The expert system must receive and accept real-time input from external programs or sensors and provide control in response.

Expert-system tools that are more specialized for a particular type of problem domain are likely to emerge as more practical than the very general development packages, according to many observers. Several companies have begun to take this approach. Robert L. Moore, vice president of process systems for Lisp Machines Inc., says, "Domain-specific expert-system tools are going to be the big market."

LMI, for example, has had its Picon expert-system tool for real-time process-control applications in several test sites for about a year now [*ElectronicsWeek*, Aug. 27, 1984, p. 33]. The first process-control expert system to go beyond the prototype stage and get out into the plant is a system that was installed last month in a Texaco Inc. refinery in Port Arthur, Texas. The Texaco system was developed by Texaco with the help of LMI using Picon.

Intellicorp's future work with KEE points towards some domain-specific enhancements, such as the work for Darpa. Another domain-specific expert system tool is TESS (for The Expert System Shell) offered by Helix Expert Systems Ltd., London. TESS is an expert-system builder for applications in banking and finance. The main requirements for a tool for this domain are compactness for desktop computers; strong, numerically accurate, double-precision floating-point arithmetic capability; and easy links to other software packages.

Another tool that comes in several versions tailored to different approaches is the Knowledge Engineering System (KES) offered by Software Architecture and Engineering Inc., in Arlington, Va. Three of the four versions have a different inferencing methodology for a particular class of problem, and the fourth is a brand-new version for embedded systems. All KES systems run on the IBM PC or PC AT, Apollo and Sun work stations, CDC Cyber 180, Tektronix 4404, and Symbolics 3600 computers. The company has 25 KES clients and about 30 installed systems. Robert Whaley, knowledge engineer at the firm, explained, "The KES systems are somewhere in between the more sophisticated systems like ART and the other more powerful micro-based systems such as Timm-PC from General Research Corp."

The KES.PS production system has a rule-based inference system. KES.Bayes is useful for expert-system development where there is an abundance of statistical data or probabilities from empirical measurement. KES.HT (for hypothesis test) represents knowledge in a frame-like description. It is useful for such problems of diagnosis as finding engine problems from exhibited symptoms. Because it is written in C, KES II, the fourth version, is more efficient and more easily embedded than a Lisp version. The initial release of KES II is the production-rule version. The frame-based and statistical-methods versions will be available later as well as possible versions in Ada and other languages.

Generating rules

In most microcomputer-based expert systems, knowledge is represented as rules that are either user-generated or automatically generated by the development system. Packages such as the Knowledge Delivery System from KDS Corp., Rulemaster from Radian Corp., Austin, Texas [*ElectronicsWeek*, May 27, 1985, p. 24], and Expert Ease [*Electronics*, Feb. 9, 1984, p. 50] generate rules from user-supplied examples. Microcomputer tools such as Expert Edge from Human Edge Software, XSYS, TI's Personal Consultant, KES, Teknowlege's M.1, and Delfi-2 require the user or a knowledge engineer to formulate the rules.

At Avignon last month, French companies showed a number of expert-system development tools, including KOOL from the Centre de Recherche Bull, Louveciennes; the Tigre-1 inference engine from Cognitech; the Alouette 85 high-level expert-system language from EDF; Clamart; Criquet from Inria, Valbonne; and Golem, from Microformatic, Paris.

Personal computer expert-system tools vary quite a bit in their rule-handling capacities. But this measure of expert-system performance is crude at best and not very appropriate, because the size and power of rules differ from system to system. However, it is still a popular comparison just as millions of instructions per second is a popular, though imprecise, yardstick for computer performance.

In that light, KDS's Knowledge Intelligence System, for example, can generate up to 16,000 rules, according to Barbara Wallach, founder and president of the firm. From a rule-size comparison point of view, this is an enormous amount considering that NASA's Navex system uses only a couple of hundred. Considered the most successful commercial application of expert-system technology to date and one of the biggest as well, DEC's XCON computer-system configuration advisor has 4,000 rules that have been generated after millions of dollars of funding and years of modification. It was worth it, however, because DEC claims that XCON saves the company about $18 million a year, as well as providing much greater customer satisfaction. ☐

Additonal reporting was done by Robert T. Gallagher, Larry Waller, and Michael B. Rand.

TOOL SET LINKS ALL STAGES OF FULL-CUSTOM IC DESIGN

Single data base lets users move effortlessly from schematic capture to simulation and layout

TECHNOLOGY TO WATCH is a regular feature of *Electronics* aimed at providing readers with exclusive, in-depth reports from companies around the world on important new technical innovations. It can cover significant technology, processes, or developments incorporated in major new products. The reports will also provide analyses of technical data so that readers can assess the impact of new developments. Amos Wilnai, founder and president of the Israeli firm Clarity Ltd., led the team that did the work described this week.

A young firm based in Herzlia, Israel, sent a group of its top people to the U.S. this month to offer a handful of selected potential customers in the semiconductor industry a preview of its integrated system for full-custom design of very large-scale integrated circuits. The company, Clarity Ltd., intends to formally introduce the system in September and ship it in December. Earlier this year, it set up Clarity Systems Inc. with offices in Sunnyvale, Calif.

Clarity's Superset, as it calls its computer-integrated engineering system, consists of software tools that run on a variety of Apollo Computer Inc.'s work stations. All tools in the system, from schematic editor to simulators to polygon layout editor, work from a single hierarchical data base, eliminating the data conversions that are now necessary when the design process moves from one type of task to another. All the tools have a uniform human interface, which uses windows and pop-up and static menus (Fig. 1), so users need not learn different commands and procedures.

"The two biggest things that differentiate us from other vendors are integration and methodology," emphasizes Ariel Sella, vice president of marketing for Clarity. "There is no control or support of design methodology" built into other systems, he says.

High-level design rules, or what Clarity calls design syntaxes, are built into Superset tools to support the methodologies used, says Sella. These syntaxes, both logical and physical, make sure that designs are correct by construction. In this way, they drastically reduce design-rule checking, circuit extraction, and redesign.

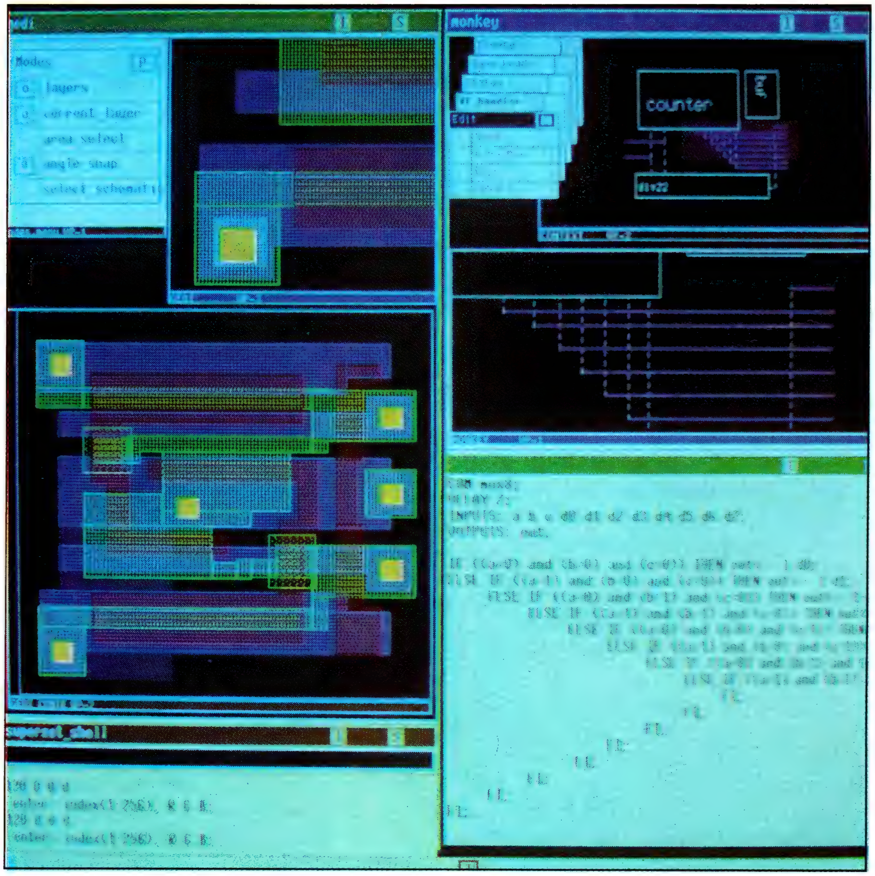
For example, there are two kinds of cells. Leaf cells, the fundamental units at the bottom of the design hierarchy, are produced only by the symbolic-layout and geometry editors, which are driven by design rules in technology files. Non-leaf cells are created hierarchically out of the nonhierarchical leaf cells in the topological editor, forming blocks. Transistors cannot be seen in the topology view.

The system enforces rules about the way blocks are designed. For instance, each must have a border, and the spacing between the border and the internal components is defined. Rules about how a port can look ensure that the system will know ports are correct when working with the blocks, thus reducing the necessary design-rule checking.

The unified data base and the version-control features of the software go a long way toward reducing the burden of design project managers; design changes are propagated automatically. The Apollo Domain network and D3M data-base management system underlying the system support projects undertaken by small teams and large. Computation-intensive tasks can be sent to servers on the network.

Clarity's data-base strategy shields the system from the peculiarities of different data-base management systems. The firm says its layered approach offers open and flexible migration to any data-base technology. A data-base handler acts as a front end to the data base: while the data-base manager stores the data on disk, the handler maintains a dynamic data structure in system memory and takes care of loading and unloading this structure from the data-base manager.

The data base contains all the connectivity and associativity data that integrates all views (such as a behavioral descrip-



1. Viewports. Superset tools run in screen windows, each of which can have multiple viewports, as in the case of the geometric editor in the left-hand window and the topology editor on the upper right. The program listing is in Clarity's behavioral description language.

tion, schematic, symbolic layout, or geometric layout) of the same block. Included is global data common to all views, such as instances of leaf cells, ports, and nets, and connectivity- and associativity-maintenance mechanisms keep the relationships between data items in different views up to date.

The system allows multiple views of the same type for the same block—reflecting the fact that one block could be implemented in many different ways—to support experimentation and version control. Both global data and private (single-view) data can be added, deleted, or modified at any time.

In developing the human interface, Clarity separated the algorithmic parts of the software from input/output-related software, which is necessarily hardware dependent, to make the system more easily adaptable to other hardware. The human-interface package used by every application is a front end that uses the Apollo graphics-metafile-resource package as a back end, but other graphics packages can be used.

The human interface

Data-base integration is visible to the user through the human interface. If three windows on the screen show a schematic, a display of simulation results, and a graphic view of that function's topology (Fig. 2), then pointing to a schematic net, a simulated waveform, or a topological-view wire will automatically highlight the associated item in the other views. There is immediate back-annotation of schematics from the simulator or topology editor.

Each window runs a different application. In each window, there can be multiple viewports—typically a working area and a context viewport showing the region around the working area. Rubber-banding can cross viewports, so that it can be used to connect two distant points: the user opens two viewports, each with one of the points, zooms in each viewport independently so details can be seen in that area, and invokes the rubber-band command to route the connection.

The three mouse buttons are dedicated to selection, commands, and arguments. To copy an element, the user selects the source element, which is then highlighted. He hits the command button, and a menu pops up; then he points to the command and hits the command button again. Finally he points to the target point and hits the argument button.

If the user wants to create in the symbolic editor a block that already exists in the schematic view, he moves the cursor to the schematic window and selects the block. He then moves the cursor to the symbolic-layout window and hits the command button. He chooses the create-block command, points to the desired position, and hits the argument button.

The system can operate in what Clarity calls the kit mode, which refers to the way a hobbyist marks a radio kit's schematic as he builds the radio. As cells are added in the symbolic-layout editor, the system automatically marks the schematic to show what portions have been instantiated.

The initial Superset applications fall into four main groups, called Strucset, Topset, Stixset, and Geoset (Fig. 3). Next year, Clarity plans to add two applications for automatic generation of programmable logic arrays and glue logic, as well as modules that address the areas of design testability and test-pattern generation.

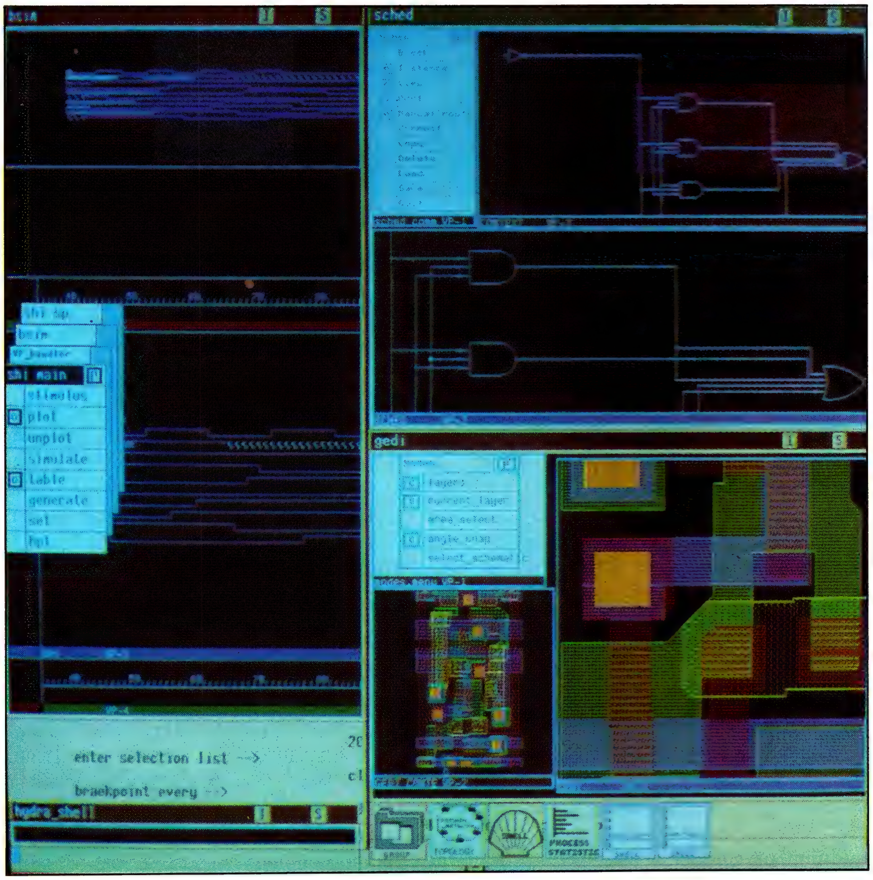
Strucset incorporates a hierarchical schematic editor, a schematic symbol editor, a mixed-mode multilevel simulator, an integrated Spice circuit simulator, a uniform simulation environment, and a symbol library. The schematic editor lets the user assemble hierarchical schematics with components, nets, ports, and symbols. Components can be at the architectural level, such as arithmetic logic units or random-access memory blocks, or they can be, at the bottom of the hierarchy, MOS transistors. Components have physical and logical attributes such as port type and port direction.

The schematic editor supports bottom-up and top-down design. It permits browsing inside a sub-block while viewing its context environment without the need to open a separate window. The schematic's connectivity is continuously updated, which makes it possible to route signals and buses in the schematic, trace connectivity across the schematic hierarchy, and simulate immediately—all without the need to extract net lists.

Connectivity may also be inserted nongraphically. For example, ground-line ports can be connected by assignment of the same signal name, without the need to explicitly draw wires. Strucset will check the completeness of a designated block, automatically detecting hanging wires, unconnected ports, and so on.

The mixed-mode multilevel simulator incorporates behavioral, functional, logic, and switch simulation algorithms. The event-driven compiled-function simulator operates on any view of Superset's data base and can therefore simulate a circuit that has been entered by the schematic, topological, and geometric editors. The simulator operates directly on the data base—which need not be flattened—and therefore needs no net lists.

Block models that can be simulated include models described by the user in Strucset's behavioral description language (BDL), models supplied by the system's library (flip-flops, counters, RAM,



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enter selection list -->
breakpoint every -->
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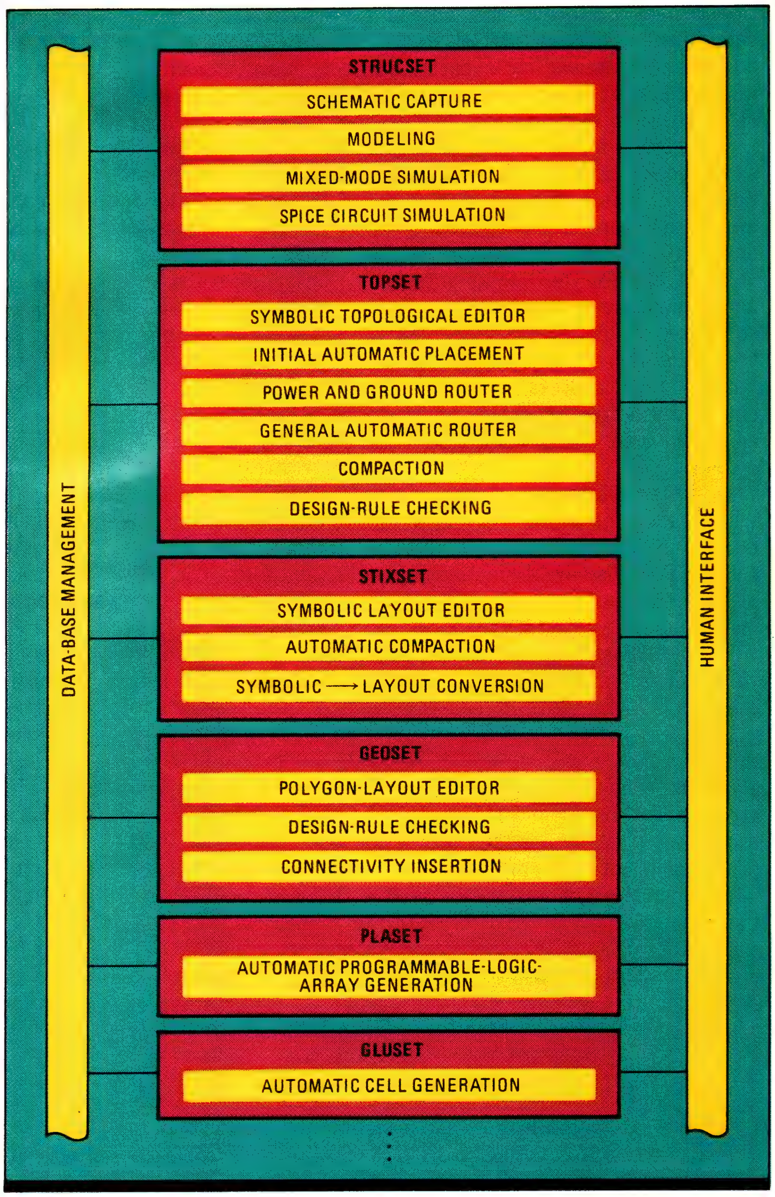
2. Connected. The single data base underlying the Superset tools allows the user to highlight portions of one view, such as in the mixed-mode simulator at left, and have the associated circuitry instantly highlighted in other views, such as in the schematic on the upper right.



3. Integrated subsets. All Superset application tools work from the same design data base and communicate with the user through a uniform human interface. The principal groupings are for design at the structural, topological, symbolic-layout, and geometric-layout levels: the two automatic generators are due next year.

and so on), logic-gate models, MOS transistor models, or a hierarchy composed of any of them.

At the behavioral, functional, and gate levels, the simulator recognizes four logic states. It provides wired-OR, wired-AND, and three-state bus modeling at these higher levels, and true analog models at the switch level.

At the switch level, simulation supports n-MOS, p-MOS, and depletion-mode transfers, as well as bidirectional operation, charge sharing, transistor impedance, and gate capacitance. Transistor delays are computed using RC analysis. Computed timing information, which is within 15% of the accuracy produced by a Spice simulation, is then stored and the simulation proceeds digitally. The simulator can detect spikes, racing, setup and hold-time violations, failure of a circuit to stabilize in a clock period, and three-state bus clashes.

The behavioral description language is a Pascal-like language that supports combinational and clocked logic. Models created with BDL are purely behavioral and do not include internal structural descriptions. Connectivity between behavioral blocks is supported by the schematic view.

A Spice analog circuit simulator is integrated within Strucset and the uniform simulation environment. It has direct access to the data base and therefore can operate not only on the circuit view but also on geometric views created by Stixset and Geoset. Clarity expects its principal use to be critical-path simulation.

The uniform simulation environment emulates a laboratory environment and its test equipment. Stimuli can be created graphically as waveforms or textually with a stimulus-preparation language. Simulation results can be plotted graphically as a function of time, emulating an oscilloscope or logic analyzer, or they can be prepared as a mixture of binary, octal, decimal, and hexadecimal tables. Simulation results can also be interactively back-annotated onto a schematic, topological, or geometric view of the circuit. One method is by attachment of a simulated light-emitting diode to a specific net: by changing colors, the LED indicates the net's state.

The topological view

Topset is composed of a hierachical symbolic topology editor; compaction, routing, and placement utilities driven by technology files; and a design-rule checker. The editor lets the user assemble blocks out of instantiated blocks, contact and wire symbols, area components (for wells), ports, and borders.

Topological symbols are defined in the technology file and have such attributes as shape, size, color, patterns, and electrical structure. Instantiated blocks can be created by Topset, Geoset, and Stixset. Because all blocks follow the same logical and physical design syntaxes, Topset is insensitive to the method that was used to design them.

In a top-down approach, the user creates blocks with estimated sizes, shapes, and ports. As the design is refined, the blocks change to reflect their internal and external environments; as the library of blocks grows through the use of Geoset and Stixset, the higher-level blocks converge to an optimized topological solution.

An embedded knowledge base aids the addition of components to the topological view. For example, when creating a new block, intersecting a wire with the block's border will automatically create the appropriate port on the block's boundary. When a wire is connected to a port, Topset automatically assigns the wire its appropriate layer designation. It will also create the necessary contact when a junction is formed between two wires of different layers.

In the grid mode, the user has full control of the placement and routing of components and is aided by a visible grid and rulers. In the gridless mode, Topset's placement, routing, and compaction utilities can be used to assure correct-by-construction topology. If the user then edits the topology, the design-rule checker is used to verify physical correctness.

Stixset includes a symbolic layout editor, a sophisticated compaction utility, and a technology-file-driven utility to convert symbols to mask geometries. Clarity expects it to be used to design the majority of leaf cells, because it yields results near manual design density. The leaf cells it produces are methodology-compliant and correct by construction.

Geoset adds a geometric editor, a design-rule checker, and a utility for inserting circuit connectivity and parameters. It will be used for design of high-density leaf cells and specialized cells that cannot be produced with Stixset. Cells designed with Geoset are also physically and electrically correct and comply with the system's design methodology. □

PC ADD-ON PRODUCTS FLOOD THE MARKET

At New York's PC Expo: a board that gives AT features to the IBM PC

The 1985 PC Expo is a mixed-media monument to the inadequacies of IBM Corp.'s Personal Computer. The IBM PC has several problems. It is slow because it is based on Intel's 8088 microprocessor—a chip that was never intended to race in the Indy 500 world of today's microcomputers. The PC cannot link with printers and other peripherals without tortuous connections. Its own color adapter supports only a modest four colors.

None of this, of course, has kept the PC from blanketing the market for business and personal computers. Not only does it benefit from IBM's forceful presence and marketing prowess, but its virtues make up for at least some of its faults. It is even being used as a process controller in factories and as an instrument in laboratories.

Moreover, the IBM PC has become a godsend to a generation of entrepreneurs who have been sparked to creativity while brooding compulsively on the PC. As Tim Riggins, an analyst with Future Computing Inc., points out, the PC has created a major area of opportunity for aftermarket sales of products that actually prolong the life of the PC. Multifunction boards fill one important product niche, and many manufacturers of add-on cards were at PC Expo, in New York, to show off what they could do to make the PC everything it isn't.

In addition to the expected—color-adapter boards, added RAM, modems, and clocks—some unclassifiable offerings—such as a modem accelerator, memory with a paging twist, a new approach to hard-disk storage—reveal that a soft PC market is being offset by a demand for enhancements that continues strong from current owners of PCs.

An unusual multifunction board, Datran Corp.'s Modem Accelerator is the company's first use of its Symbolic Tokenizer, a processor that converts character strings into language word and phrase tokens at about one page per second. "The Modem Accelerator is a microprocessor oriented toward human language," says Datran vice president Ken Widelitz.

The prototype tokenizer uses a ROM-based dictionary that contains 28,000 words and 4,000 phrases. The command Compress Filename compresses the text—using a 5-bit assignment scheme rather than ASCII—to one third its original size. Then, the board's accelerator transmits data at three times the normal speed of the modem. Another Modem Accelerator at the other end decompresses the data.

Further, the Modem Accelerator's dictionary functions as a fast spelling checker in a post-document-preparation mode. The retail price of the Modem Accelerator is $795. For original-equipment manufacturers, the Symbolic Tokenizer is available separately as a plug-in card, priced at $799, for such applications as an encryption device or integration into a network file server.

A more conventional peripheral, the Zipmodem from Deca Tek Inc. is a dial-up, plug-in alternative to leased lines that moves data at the rate of 9,600 b/s over existing telephone installations—an impressive upgrade from the usual 1,200-b/s rate. Beyond that, the Zipmodem incorporates protocol-conversion software, which is not ordinarily a modem feature but is desirable for security reasons.

Sixteen colors. Color and extended graphics capabilities, supported by an additional 32-K bytes of memory and reinforced by software drivers, come on a board that's also beefed up with a parallel port and an optional battery-backed clock-calendar. STB Systems' Colorific supports resolutions of 640 by 200 pixels for four colors and 320 by 200 pixels for 16 colors, while the software package, PC Accelerator, provides drivers for the extended-graphics display of Lotus 1-2-3, Symphony, and Framework. For standard graphics display, Color-

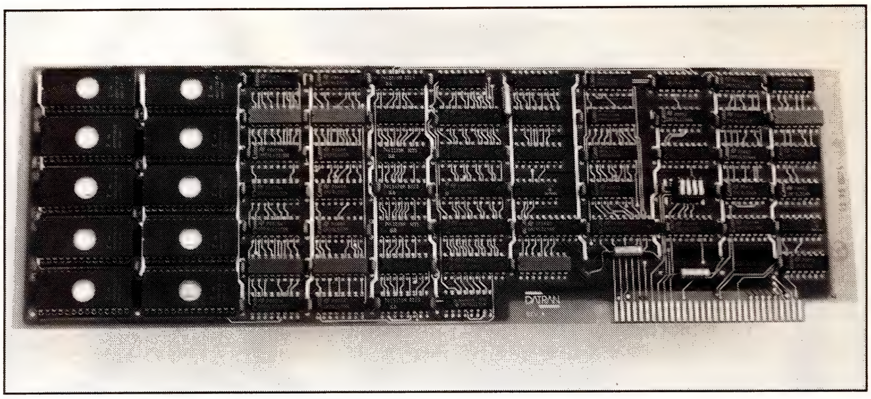
MULTIFUNCTION BOARDS TACKLE IBM PC's WEAKNESSES

Company and product	Memory	Color graphics support	Modem	Ports	Protocol converter	Calendar-clock
Deca Tek Inc. ZipModem	No	No	9,600 b/s	No	SNA/ SLDC	No
Emulex Corp. Persyst Color Combo Card	384-K bytes RAM	Standard IBM resolution: 320 by 200 for four colors; 640 by 200 for one color	Data-transmission equipment support	1 Parallel and 1 RS-232-C serial, programmable from 50 b/s to 9,600 b/s	No	Option
STB Systems Inc. Colorific video board	32-K bytes RAM	640 by 200 for four colors; 320 by 200 for 16 colors	No	1 parallel	No	Option
Mega-Omega Systems Inc. Companion Card plus SPC Card option	2 megabytes RAM	No	No	1 parallel, 1 serial	No	Real-time clock
Datran Corp. Modem Accelerator	ROM-based dictionary of ~30,000 words and phrases, triples disk-drive storage	No	When added to 9,600-b/s modem, triples modem's rate	No	No	No

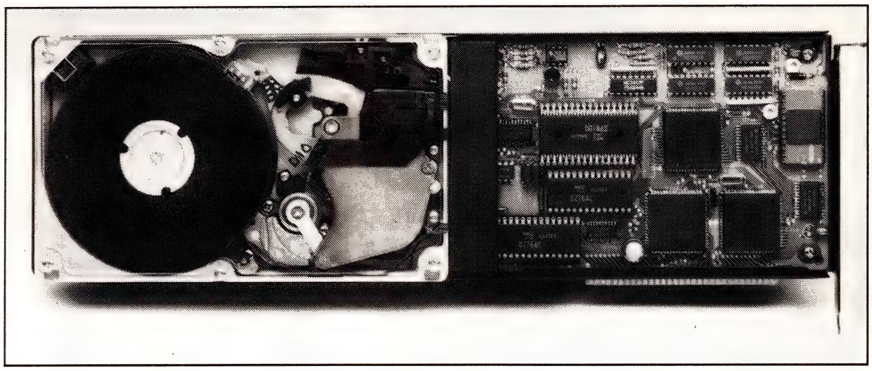
ific supports IBM standard resolutions. It is priced at $275.

Emulex-Persyst's Color Combo Card flexes six ways for individual configuration—up to 384-K bytes of socketed RAM in increments of 64-K bytes, serial and parallel ports, and clock-calendar. Color Combo uses space-saving proprietary custom chips to pack the board and, in software, offers print spooling plus RAM disk emulation.

The wild ones. Some single-purpose boards show imagination too. Thus, when Applied Reasoning Corp. put an Intel 80286 chip on a plug-in board and added proprietary interface software and 2 megabytes of RAM, the result was a "softboard"—a separate processor board called the PC-Elevator that lets the PC or PC/XT run PC AT applications under a DOS 3.0 or 3.1. environment. Concurrently, PC-Elevator relegates the PC's 8088 chip to I/O processing. It speeds up the Personal Computer to a claimed 50% faster than the AT, but runs existing PC programs "as is." With 2 megabytes of RAM, the board lists for $2,495, and volume discounts are offered.



Compression chamber. The modem accelerator was born when Datran Corp.'s president figured out how to cut the cost of receiving stock quotations by modems: compress the bits.



Hard bargain. Plus Development Corp. packs a 10-megabyte hard disk and controller on a 4-by-13-by-1-in. plug-in card, upgrading the standard IBM PC to the performance of a PC/XT.

The Companion Card from Mega-Omega Systems uses the Lotus-Intel expanded-memory specification to work with the newly announced versions of Lotus 1-2-3, Symphony, and Framework, expanding system memory to 2 megabytes beyond the PC's natural boundary of 640-K bytes. These 2 megabytes can be used as either system memory or can be configured as Ramdisk, and Ramdisk software is included with the card. When the Companion Card is paired with the same company's SPC (serial, parallel, clock) Card option, the user acquires serial and parallel ports, a real-time clock, and a game port. The price is $695 with 1 megabyte of RAM.

Hanzon's add-in board lets a PC monitor any RS-232 asynchronous data line at rates up to 19,200 baud. The data can be monitored, displayed, recorded, or simulated for use as a test signal, and the test engineer can choose to display up to 21 lines of data in a variety of codes. In simulation mode, the board performs "what if" testing. This data-line-analysis board, which sells for $1,495, comes from Hanzon Data Inc.

AST Research Inc., manufacturer of Sixpakplus and Advantage, reports a strong third quarter with revenues up 88%. One of its recent offerings, Rampage!, puts up to 2 megabytes of paged memory on the PC, something especially desirable for swapping 16-K byte pages in and out of the PC's normal address range, in large spreadsheet programs.

Rampage! also supports "split memory addressing," developed out of AST's Advantage! for the PC AT, which rounds out conventional memory to 640-K bytes at the same time adding remaining Rampage! memory as expanded memory. Rampage! uses an enhanced superset of the Lotus-Intel Expanded Memory Specification (EMS), which the company calls more flexible than the specification itself. A software driver and a spooler are also part of the package, which is priced starting at $595 with 256-K bytes of memory.

An interesting twist in hard-disk packaging technology has surfaced in the recently introduced Hardcard from Plus Development Corp. The 10-megabyte 3½-in. Winchester disk drive—complete with electronics, controller, and file management plus one-time-installation software—has been squeezed to fit on a PC add-in board.

Offered as an upgrade to IBM machines, it also goes into the AT&T PC 6300. Average access time is 65 ms with Hardcard, and standard IBM 3370 heads are used in the product, as is cobalt-doped media and a modified SASI controller. Hardcard, selling for $1,095, will be available in October. *–Ann Jacobs*

COMPANIES THAT BEEF UP THE IBM PC

Datran Corp., 10519 Lauriston Ave., Los Angeles, Calif. 90064.
Phone (213) 474-3684 [Circle reader service number 400]
Deca Tek Inc., 4754-C N. Royal Atlanta Dr., Tucker, Ga. 30084.
Phone (404) 934-7695 [Circle 401]
STB Systems Inc., 601 N. Glenville, Suite 125, Richardson, Texas 75081.
Phone (214) 234-8750 [Circle 402]
Emulex Corp., 3545 Harbor Blvd., P.O. Box 6725, Costa Mesa, Calif. 92606.
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Phone (408) 946-3700 [Circle 408]

COLOR COCKPIT DISPLAY STAYS BRIGHT IN THE LIGHT

High-resolution CRT's building-block architecture is adaptable to various military planes

With military plane designs integrating CRT displays into cockpit instrumentation, the problem of reading data on a color display in bright sunlight comes to the fore. Now, an advanced color display system from the Allied Bendix Flight Systems Division, Teterboro, N.J., has been designed to overcome this problem.

The new display, with a building-block architecture that can meet a variety of military aircraft requirements, is the first aircraft color display system to include a new high-resolution, high-brightness CRT designed by Tektronix Inc., Beaverton, Ore. The CRT provides a threefold improvement in brightness over conventional color CRTs, and it can operate in vibration environments up to 8.2 g root-mean-square.

With the new CRT, a user can display raster sensor data on a color display in bright sunlight. In addition, each display unit is microprocessor-controlled to maintain precise color tracking regardless of ambient lighting.

This advanced color display stems from a wide range of avionics experience at Bendix FSD on related programs on the F-18 and F-20 fighter aircraft, the AFTI/F-16 aircraft research program, and the model 360 helicopter avionics management control system.

This is the first display unit of its type to use a MIL-STD-1750 A (the standard instruction-set architecture for processors used by the U.S. Air Force) processor programmed in Jovial higher-order language. The system provides electrically erasable solid-state memory that can be reprogrammed from a front chassis connector so that mission changes may be accommodated quickly.

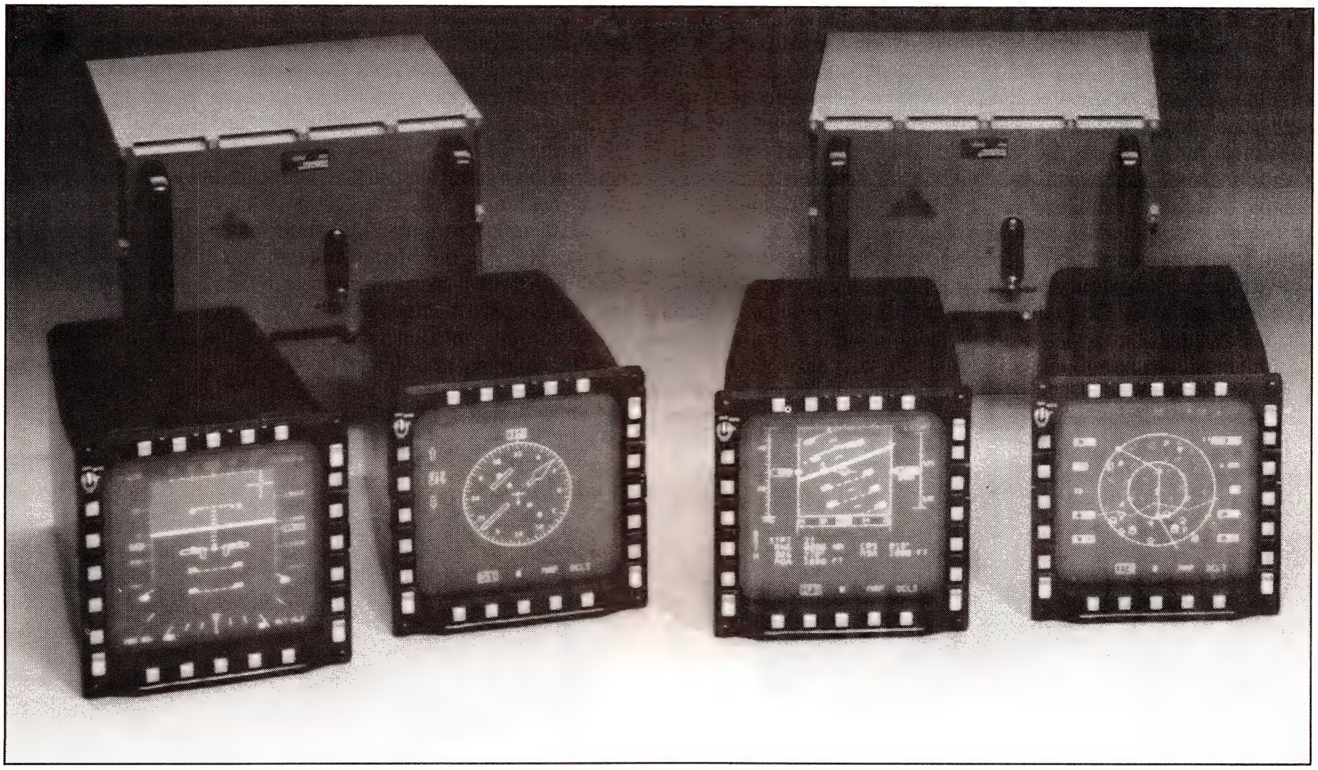
The new advanced color display system consists of the display processor with a three-channel digital symbol generator and dual remote terminals that conform to MIL-STD-1553B (a multiplexed data bus for military systems). Because the display processor unit was designed with gate arrays, standard cells, and custom very large-scale-integrated circuits, including the display processor IC, designed by Bendix, the display system is very compact and lightweight. It also features low power consumption, high functionality, and relatively low-cost mechanization.

The processor, a rack-and-panel type measuring 11.39 in. wide by 7.64 in. high by 12.76 in. deep, weighs 36 lb. It requires 200 V maximum, three phase, 400 Hz. Mean time between failures for the processor is 2,500 h, for the display, 4,000 h.

With the building-block architecture, stroke or raster symbol generators and memory-expansion modules can be quickly added or removed from the system by simply changing the number of cards. The display system under development at Bendix consists of one processor and three symbol generators that can drive three displays, plus one repeater that can serve as a fourth display with the same format as the other three.

System redundancy, critical in a military aircraft, comes from primary and secondary inputs from two processors to each display unit. In a system with four processors that drive eight display units, three of the four processors can fail, yet three displays with unique formats plus a repeater would remain active. The number of processors and displays can be varied according to mission and redundancy requirements.

Each processor contains 96-K of EEPROM, so the system



can be expanded in the future. The system can be modified to drive monochrome displays or a combination of color and monochrome. With three or more spare cards in the processor unit, it can also be expanded to include bus-controller and raster-symbology functions.

Other features of this advanced color display include radiation-hardened circuitry; a self-test pattern contained within the CRT unit; displays in stroke only, raster only, or a combination of both; raster displays in both 525- and 875-line raster video; raster borders; and a video tape recorder that can accommodate both stroke and raster information.

No prices for the display system have been set yet, but the manufacturer says that it intends to begin deliveries this summer. *–Jerry Lyman*

Allied Bendix Aerospace, Flight Systems Division, Route 46, Teterboro, N.J. 07608. Phone (201) 226-2000 [Circle 338]

PHILIPS AIMS MULTISTANDARD TV TESTERS AT U.S.

For Philips International B.V., versatility in equipment design is the key to maintaining its lead on the $50 million European market for TV test-pattern generators and to strengthen its position in the much larger U.S. market for such devices. With these goals in mind, the Dutch electronics giant last month unveiled a new family of microprocessor-controlled multistandard color-pattern generators at the International Television Symposium and Technical Exhibition in Montreux, Switzerland, and will introduce them in the U.S. at the September Wescon show in San Francisco. The family covers all TV standards in use around the world today.

In Europe at least, "the market for pattern generators has slowed down in recent years," notes Ted Molle, product manager for audio and video test equipment in the Eindhoven-based Industrial and Electro-acoustical Systems Division. "But as cable-TV and videotex-based services are being offered in more and more countries, the market is picking up again," he says. For Europe, Molle predicts a rise of between 10% and 14% a year in the near term.

After Philips, the heaviest player on the European market is West Germany's Grundig AG, which actually is under control of the Dutch company and has financial links to it. Philips, with its far-flung sales organization throughout Europe, is by far the leader, however. In the U.S., though, Philips is still an also-ran.

"Our development efforts were aimed at a line of instruments as versatile as possible," Molle says. The result: three units, each offering a choice of more than 70 combinations of test patterns—those arrays of bars, lines, and symbols that technicians use to check sharpness, linearity, resolution, brightness, and other display parameters. For ease of operation, each instrument features electronic numerical radio-frequency selection.

The PM5515 is adapted to the NTSC and PAL color TV standards plus all PAL-derived standards used around the world. The second unit, the PM5516, operates according to the French Secam TV system and to the various Secam standards used in different countries. The third is the PM5518, which handles all three standards plus those derived from them.

Philips believes the instruments are the first multistandard types around. With them, technicians no longer need a specific test-pattern generator for a specific TV standard or its derivative. They provide full rf coverage, including the intermediate-frequency band, the TV very-high and ultrahigh frequency bands, and S-band frequencies used for cable TV channels. Resolution is 250 kHz for rf and 100 kHz for i-f.

Special versions of the basic instruments are designed for testing teletext information display services used in some European countries, such as Antiope, the French service. Special versions are also available for PAL stereo-FM-equipped TV sets, with sounds used as test criteria. The teletext/Antiope versions offer five test pages as well as a test pattern to align and check receivers and decoders.

The user selects test patterns from a multifunction keyboard. Up to 10 independent rf frequencies or TV channels, together with any required patterns and sound modulation, can be stored and recalled from a nonvolatile memory.

In the U.S., the PM5515 PAL-NTSC version is priced from $1,250 to $1,900, depending on options; the high end of the range is for a generator that includes the teletext and stereo options. Depending on options, the PM5516 Secam and PM5518 multiprotocol models range from $1,300 to $1,750 and $1,500 to $2,050, respectively. Delivery takes from four to eight weeks after receipt of order. *–John Gosch*

Philips Test & Measuring Instruments Inc., 85 McKee Dr., Mahwah, N. J. 07430. Phone (201) 529-3800 [Circle 339]
Philips Industrial & Electro-acoustic Systems Division, TQIII-4 Eindhoven, the Netherlands [Circle 390]

EPROM-based computer chip cuts programming time

Microcomputer chips with plenty of on-board EPROM are now available, but the time it takes to load software into them is still a problem. Addressing the need for quicker loading are two EPROM-based 8-bit microcomputers that take only about 7% of the time it takes to program conventional EPROMs, the manufacturer claims.

Built in 2-μm n-MOS technology, the Am9761AH borrows the adaptive device-programming algorithm (sometimes called interactive or intelligent programming) used on the manufacturer's EPROM memory chips. The chip's 8-K bytes of EPROM can be set in 24 s compared to 6½ min using conven-

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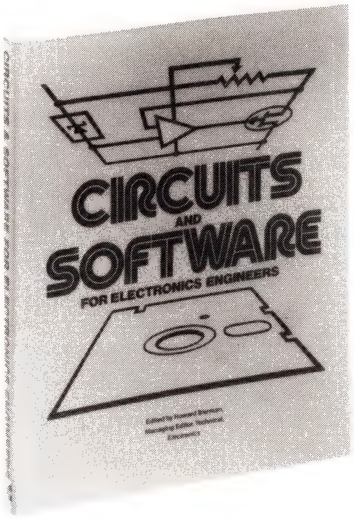

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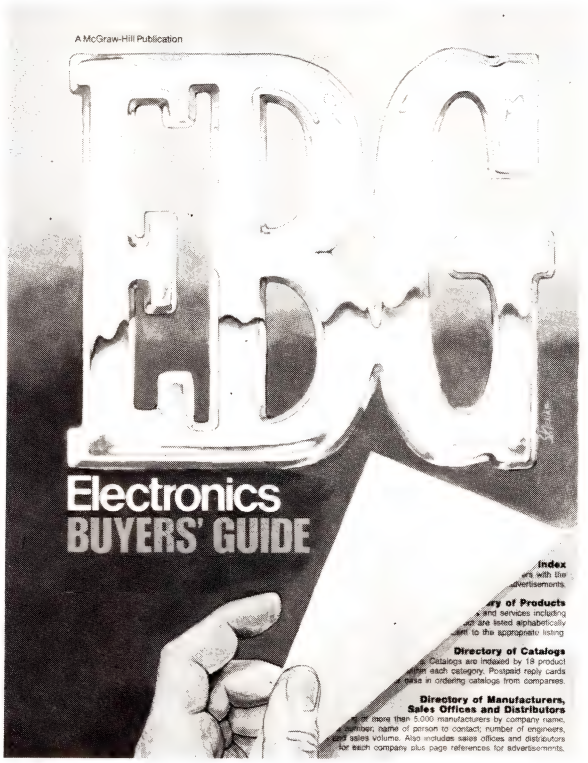
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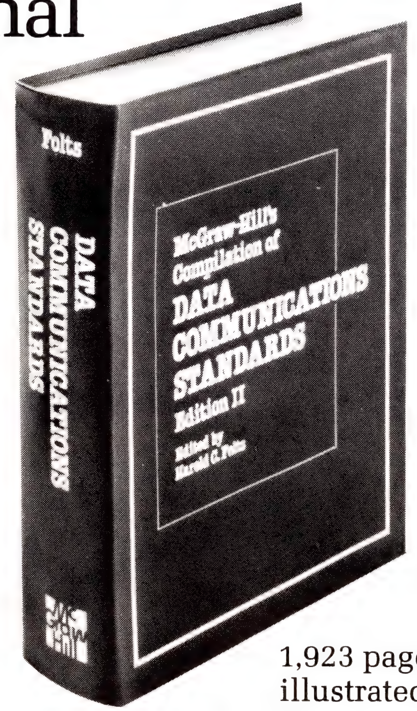
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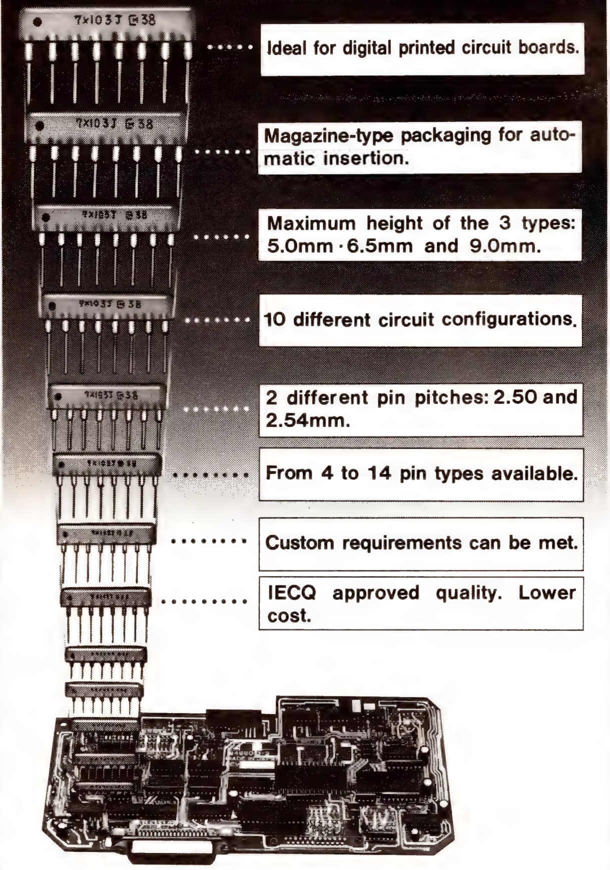

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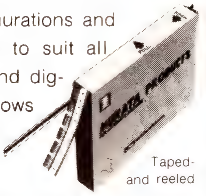

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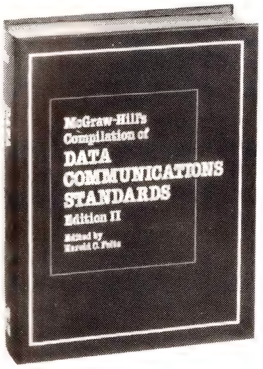

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tional techniques. A 4-K-byte version, the Am8751H, is also being made from the same die design.

The manufacturer's algorithm achieves minimum programming time by sensing the actual charge storage efficiencies of each byte of memory so no time is wasted. This is significant, explains a company spokesman, "because microcomputer customers using programmers in volume production might be able to get by with less equipment, capital costs, and labor overhead."

Samples of 12-MHz parts are now available. The Am9761AH sells for $73.70 and the 8751 goes for $63 each in lots of 100 pieces.

Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94088. Phone (408) 732-2400 [Circle 340]

Three-chip set provides full modem capability

Combining CMOS and n-MOS technologies, the R212DP three-chip modem set provides complete capability for 1,200-b/s full-duplex, dial-up transmission.

The set handles the entire modulation/demodulation process, high- and low-band filtering, automatic adaptive equalization, and complete auto-dialing functions. The R212DO, which is Bell 212A and 103 compatible, includes an RS-232-C interface to ease integration with a personal computer, box modem, or terminal.

In quantities of 1,000, the set costs $35. Evaluation pc boards are available for $315 each, and shipments are scheduled to begin in July.

Rockwell International Corp., Semiconductor Products Division, 4311 Jamboree Rd., P.O. Box C, Newport Beach, Calif. 92660. Phone (714) 833-4700 [Circle 341]

Mixed analog-digital set builds complete 300-b/s modem

Containing all the circuitry needed to handle the signal-processing tasks of a Bell 103-compatible modem, two 300-b/s modem ICs are manufactured in a proprietary process that combines analog and digital circuitry on one chip.

The SC11002, which requires ±5-V power supplies, and the SC11003, which needs only one +5-V power supply, both feature full-duplex answer and originate operation and include high- and low-band filters, a frequency-shift-keyed modem, a line driver and receiver, and timing and control circuits. Both can be customized for specific applications.

Housed in 20-pin plastic DIPs, samples of the two parts are available now. Production quantities will be delivered approximately 12 weeks after receipt of order. In 100-unit lots, the SC11002 costs $25.50; in the same quantity, the SC11003 costs $28.

Sierra Semiconductor Corp., 845 W. Maude Ave., Sunnyvale, Calif. 94086. Phone (408) 720-8955 [Circle 342]

Fast GaAs cell array has ECL-compatible I/O

Claiming to be 50% faster than any other gallium arsenide cell array on the market, the HMD-11100 can drive a 50-Ω, 1-pF load at up to 3 GHz.

The chip has a medium-scale integration level of 300 equivalent gates and features both ECL and GaAs-compatible I/Os. It contains a variety of gates, inverters, flip-flops, amplifiers, and buffers. Able to operate in temperatures from –55°C to +85°C, the array is available in die form or in a 48-pin metal-bottomed flat pack that has been qualified by the manufacturer for high-speed GaAs IC applications.

Standard pricing for the cell array program is $65,000, and the first circuits can be delivered within 16 weeks of a basic audit of the customer's layout.

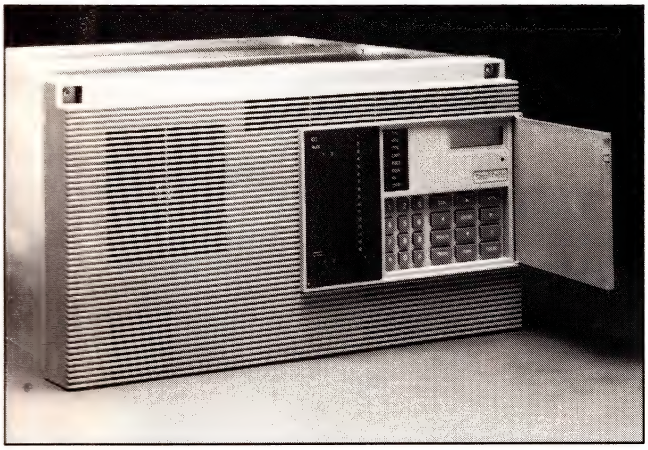
Harris Corp., Microwave Semiconductor Division, 1530 McCarthy Blvd., Milpitas, Calif. 95035. Phone (408) 262-2222 [Circle 343]

Data-communication controller can run up to 8,000 modems

Capable of controlling a worldwide dial-up network of up to 8,000 modems, the Multiple Data Set II manages high-density data-communication facilities and networks.

The MDS II is a family of products consisting of the VA1690 chassis, VA990 control card, VA2190 power-supply card, VA4491E triple modem, and VA9000 system controller. The rack-mountable chassis has 16 slots for modems or other data-communications products, a slot for the chassis controller, and an additional slot for future growth.

The modem, which is compatible with V.22, Bell 212A, and Bell 103 standards, can be configured for either the switched telephone network or two-wire leased lines. It provides full-duplex synchronous and asynchronous operation at 2,400 and 1,200 b/s, and asynchronous operation from 0 to 300 b/s. The system controller can control up to 256 MDS-II chassis and more than 8,000 modems.



The VA1690 chassis comes equipped with a VA990 controller card and two VA2190 power supplies; it costs $3,260. The VA4491E modem costs $1,095, and the VA9000 system controller, consisting of an interface board for an IBM Corp. or compatible personal computer and proprietary software, is priced at $3,500. Shipment on all members of the family will begin in July.

Racal-Vadic, 1525 McCarthy Blvd., Milpitas, Calif. 95035. Phone (408) 946-2227 [Circle 367]

Plasma etcher bows for chlorine-related chemistries

Showing its commitment to plasma etching, GCA Corp. has unveiled the Waferetch 616, a triode etcher for chlorine-related chemistries. The triode chamber allows plasma etching, reactive-ion etching, or a combination of the two.

The Waferetch system etches aluminum and its alloys with uniform, repeatable results while controlling and tailoring a process to specific requirements. An in-situ passivation process solves the post-etch corrosion problems usually associated with etching aluminum. Power can be varied between electrodes in any desired proportion to adjust the anisotropy and selectivity of an etch.

The etcher also features an advanced end-point-detection system for process monitoring and control. Critical-dimension

control can be to within ±0.06 μm, 3 sigma, on oxide wafers with as little as 2% exposed area. The Waferetch 616, priced starting at $350,000, will be available during the second half of the year.

GCA Corp., 209 Burlington Rd., Bedford, Mass. 01730.
Phone (617) 275-5400 [Circle 368]

Repair system uses ion beam to fix defective photo masks

Using a focused ion beam, the IBT Microtrim repair station corrects clear defects as small as 0.25-μm on high-resolution photo and X-ray masks and reticles. The process, which is reversible, can hold the dimensional tolerances to ±0.05 μm.

For under $1 million, the system fixes clear and opaque defects on up to 6-by-6-in. wafers with 0.5-μm substrates. Providing single-frame ion-microscope or multiple-scanned real-time video images, it can be connected with mask-inspection gear. Delivery will begin in early 1986.

Ion Beam Technologies, 123 Brimbal Ave., Beverly, Mass. 01915.
Phone (617) 927-7551 [Circle 365]

Program lets IBM PCs search unstructured information

Information bases, unlike data bases, can accommodate unstructured textual information, says the maker of Textbank/PC, a software program for managing textual information on the IBM Corp. Personal Computer AT and PC/XT.

With Textbank/PC, users can build and have access to information bases at an individual work station. The program performs search and access operations in seconds for any word, part of a word, word proximity, or word combination. The program costs $995 each in quantities up to nine.

Group L Corp., 481 Carlisle Dr., Herndon, Va., 22070.
Phone (703) 471-0030 [Circle 344]

Program gives AI capability to Unix-based microcomputers

Users of Unilisp can adapt advanced artificial-intelligence applications to Unix-based microcomputers. The complete software-development environment has a full segmented object list as well as optional math, statistical, and graphic add-on object lists for system development, according to the manufacturer. The Unilisp kernel requires just 32-K bytes of memory on most Unix machines, permitting the concurrent use of the program for knowledge networks, natural-language front ends, and building interpretive filters.

Available on Digital Equipment Corp.'s VAX, Microvax, Microvax II, and Pro 300 series, it can also be adapted to Intel Corp.'s 310, the IBM Corp. Personal Computer AT, and other systems from Sun, Apollo, Zilog, and Tandy.

The package can support Unix I/O specifications, access physical memory, and perform a variety of editing functions. A demonstration disk is available for a $30 fee that can be applied toward the actual purchase price of $895. Substantial discounts to original-equipment manufacturers apply.

R/L Group, 7623 Levison St., El Cerrito, Calif.
Phone (415) 527-1438 [Circle 346]

Package converts IBM PCs into software-development systems

Software developers can produce and distribute True Basic programs for the IBM Corp. Personal Computer and compatibles with the Runtime package for only $500.

The package offers a special developer's tool kit of library routines that provide fast, direct access to the IBM PC's basic input/output system and disk-operating-system routines. The package includes a license that gives developers unlimited rights to distribute software that incorporates Runtime.

True Basic Inc., 39 S. Main St., Hanover, N.H. 03755.
Phone (603) 643-3882 [Circle 345]

Integrated program lets PC/XT manage industrial operations

Completely menu-driven, the Factory-Pac 2 is an integrated set of software modules for the IBM Corp. Personal Computer XT for computer-aided management of industrial operations. The package provides logging, high-resolution graphics, a spreadsheet, and command-set functions.

Logging, display, and report criteria are specified by the user in an initial setup session. Data from the production facility is logged and stored in a data base, which is then used in other functions. In addition to providing its own spreadsheet, the program can generate a spreadsheet file that is compatible with other spreadsheets on the market, the company says.

Factory-Pac 2 can interface with many popular programmable controllers, and its command-set capabilities allow controller parameters to be communicated to the process controller from a predefined file. Because of the program's modularity, prices range from $2,350 to $7,500. Delivery is five to six weeks after receipt of order.

Action Instruments Inc., 8601 Aero Dr., San Diego, Calif. 92123.
Phone (619) 279-5726 [Circle 347]

Micro's two processors give it the power to run Unix

Dual M68010 microprocessors allow the P/20 multiuser microcomputer to run under AT&T Bell Laboratories' Unix operating system. The two processors operate at 10 MHz with no wait states and share their work, with one acting as a job processor and the other as a direct-memory-access controller for I/O tasks. Both access the same block of memory.

Designed for applications including office automation, transaction processing, and industrial control, the P/20 offers two bus interfaces: Multibus and Small Computer Systems Interface bus. With Multibus, users can add an 8-port (serial) controller board to provide up to 16 serial ports, as well as a Multibus Ethernet controller to link the system to a local-area network. The SCSI bus accepts up to seven storage devices, including 142 megabytes of Winchester-disk storage, floppy-disk drives, and tape-backup systems.

The computer comes with built-in sensors to protect it against adverse operating conditions such as heat or power failure. A standard configuration with 24 megabytes of hard-disk storage, 1 megabyte of unformatted floppy-disk storage, and 512-K bytes of main memory costs $6,025; it is available immediately.

Plexus Computers Inc., 3833 N. First St., San Jose, Calif. 95234. Phone (408) 943-9433 [Circle 348]

PC AT-compatible computer runs faster than the original

The Series 5000 microcomputer is not only fully compatible with the IBM Corp. Personal Computer AT, its maker says, but it surpasses it on almost every front as well.

Using an 8-MHz 80286 microprocessor along with a 150-ns interleaved memory with no wait states, the Series 5000 is said to operate at speeds 55% to 100% faster than its IBM competitor. The computer uses direct-memory-access controllers to boost speed by offloading the CPU—the result is a disk-access time 25% faster than the PC AT. An optional 80287 math coprocessor can be added to further improve system throughput.

The computer comes in two configurations. The model 100, priced at $3,395, has 512-K bytes of memory, a 1.2-megabyte floppy-disk drive, an RS-232-C serial port, a Centronics parallel printer port, a clock/calendar with battery backup, and a PC AT-compatible keyboard. The model 200, which costs $5,215, adds a 27-megabyte formatted 5¼-in. hard disk with a 28-ms access time to the basic model.

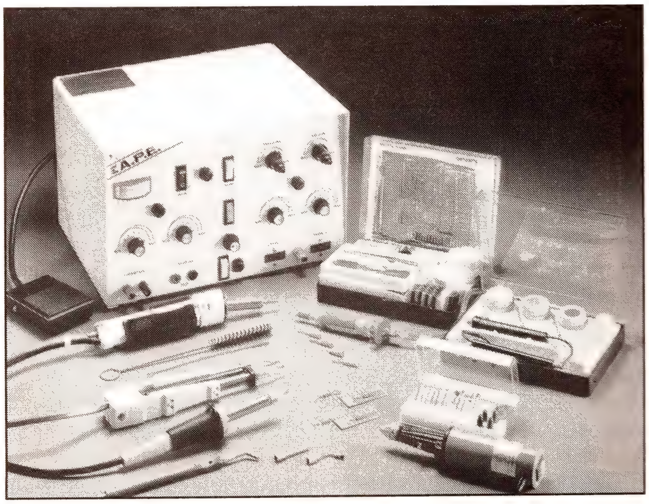
Micro Five Corp., P.O. Box 5011, 3560 Hyland Ave., Costa Mesa, Calif. 92626. Phone (714) 957-1517 [Circle 349]

Repair station fixes boards with surface-mounted devices

Repairing boards that contain surface-mounted devices is usually a difficult task, but the model SMD-2500 repair station has everything needed to make the job easier. The SMD-2000 features a precision solder-paste-dispensing system to aid in the reattachment of SMDs.

Also included is an SMD-placement tool with three tip pairs, which allows fast removal and replacement of SMDs. The system, which is priced at $2,395, is also useful for boards with conventional through-hole components.

Automated Production Equipment Corp., 142 Peconic Ave., Medford, N.Y. 11763. Phone (516) 654-1197 [Circle 363]



Machine uses light beam to count a stack of boards in 3 s

A noncontact machine rapidly counts the number of pc boards in a foot-high stack in just 3 s. Called the Stak-Kounter/50, the machine handles boards from 0.020 to 0.125 in. thick and with dimensions up to 18 by 20 in.

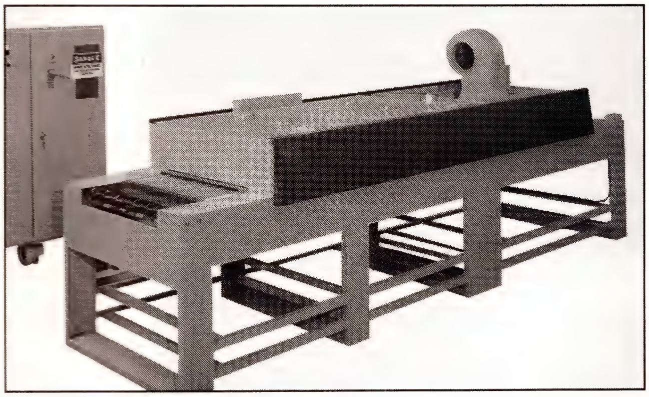
A stack can contain boards of different thicknesses (variations to 20%) without affecting accuracy of the count. Counts can be consecutive or cumulative; cumulative tasks can be interrupted at any point to run a different stack without losing the original count.

The Stak-Kounter/50 uses a special collimated light beam focused on the stack. Individual boards in the stack reflect the light beam back to a sensitive photocell that sends a flow of pulses to a minicomputer that translates them into numbers on the readout panel. Accuracies are over 99.5%. The machine is priced at $6,400.

Spartanics Ltd., 3605 Edison Pl., Rolling Meadows, Ill. 60008. Phone (312) 394-5700 [Circle 362]

Infrared oven uses conveyor for continuous production

A conveyorized electric infrared oven for curing solder masks such as SR1000s and SR2020s uses six 8.8-kW heaters with 1,500°F elements, which enable the system to reach its processing temperature in seconds. The oven, which is designed for continuous in-line production, conveys pc boards through an insulated tunnel of IR energy, eliminating many of the material-handling problems and delays associated with batch processing.



The oven has center and edge zones so the temperature is uniform across the conveyor. There are also separate zones in the directions of travel so the user can set temperature profiles easily. A silicon-controlled-rectifier system regulates the voltage to the IR heaters by a thermocouple feedback loop, maintaining a constant temperature in each zone.

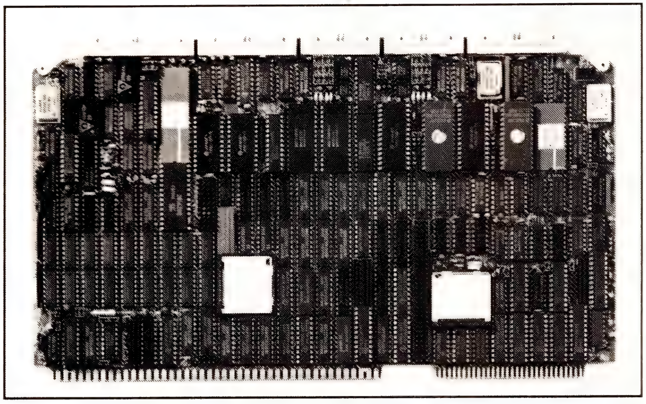
Simple adjustments also enable the user to set the dwell time of the product in the oven. Available 10 to 12 weeks after ordering, the ovens are priced from $8,000 to $40,000 depending on size.

Glenro Inc., 39 McBride Ave. Extension, Paterson, N.J. 07501. Phone (201) 279-5900 [Circle 364]

80186-based Multibus boards carry on-board interfaces

Two 80186-based single-board computers for Multibus also have on-board interfaces for Ethernet local-area networks, hard- and floppy-disk drives, as well as extensive RS-232-C serial-interface capabilities.

The CP-2000 communications processor has up to 512-K



bytes of RAM with parity, a full Ethernet interface, and octal RS-232-C and RS-423 serial channels. The FP-2000 file processor also has up to 512-K bytes of RAM, but in addition it supports dual 5¼-in. hard-disk drives, four floppy-disk drives, and up to four other RS-232/423 interfaces.

The CP-2000 follows the IEEE-802.3 Ethernet specifications at a data rate of 10 Mb/s. Memory is triple-ported to the CPU, the 82586 LAN coprocessor, and the Multibus. Both boards are equipped with what the manufacturer calls a mailbox—a facility to support multiple-instruction, multiple-data computer applications.

Prices for both boards starts at $2,995, which includes only 128-K bytes of RAM. A real-time executive with debugging monitor costs $250.

Matrox Electronic Systems Ltd., 1055 St. Regis Blvd., Dorval, Quebec, Canada H9P 2T4. Phone (514) 685-2630 [Circle 353]

1-megabyte memory board boosts capacity of HP 3000

Owners of Hewlett-Packard Co. HP 3000 computer systems can upgrade their systems' memory capacity with the HP-401, a 1-megabyte memory add-on board for models 39 through 48 of the 3000 series.

The board can be installed without modification to the CPU or operating system, according to the manufacturer. The system will automatically recognize the additional memory and take advantage of the boosted capacity.

Backed by a lifetime guarantee, the $5,400 HP-401 is available for immediate delivery. Two other versions, one with 2 megabytes and the other with 4 megabytes, are under development, as is a 1-megabyte board for the HP 3000 models 64 and 68.

EMC Corp., 12 Mercer Rd., Natick, Mass. 01760.
Phone (617) 655-6600 [Circle 354]

Am29325-based array processor runs on Microvax II and others

Gaining speed and efficiency from the Am29325 very large-scale integrated arithmetic processor, the Zip 3232 array processor can serve a variety of computer systems, including Digital Equipment Corp.'s Microvax II.

Intended for the original-equipment manufacturer that addresses signal, image, and scientific processing, the Zip 3232 provides 16-megaflops performance for the Microvax II at one fourth the cost and on one third the real estate that comparable systems provide on the VAX, the manufacturer of the three-board set claims. In single units, the Zip 3232 costs about $940 per megaflops; in quantity orders the price can go as low as $610 per megaflops.

The use of AMD's part is a departure for Mercury, whose other array processors used chips from Weitek. The AMD part's ability to perform both multiplication and addition eliminates pipelining between separate devices, the company says, resulting in improved programmability and greater efficiency. Built for Q-bus or Multibus systems, the Zip 3232 comes in two versions.

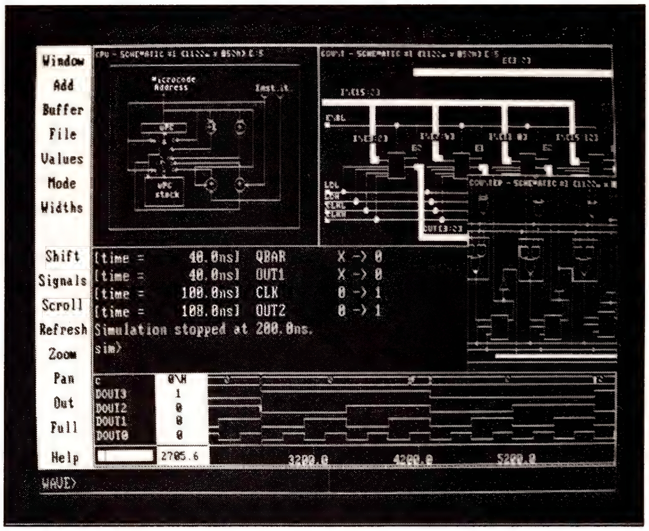
The 16-megaflops version is priced from $9,750, the 8-megaflops version at $7,500. Memory can be expanded in units of 2 megabytes or 512-K bytes, for $3,900 and $1,950, respectively.

Mercury Computer Systems Inc., 600 Suffolk St., Wannalancit Tech Center, Lowell, Mass. 01854.
Phone (617) 458-3100 [Circle 352]

Software turns IBM PC/XTs, ATs into engineering work stations

Written to turn an IBM Corp. Personal Computer XT or AT into a complete computer-aided engineering work station, the Workview Series of software programs performs design, documentation and communication functions.

Workview supports schematic entry, interactive logic simulation, waveform processing, document processing that merges text and graphics, and communication between the PC and mainframes, superminicomputers, and other PCs and work stations. The software package, which requires a computer with at least 512-K memory, supports a variety of standard graphics boards and an optical mouse.



```
[time =      40.0ns]  QBAR      X -> 0
[time =      40.0ns]  OUT1      X -> 0
[time =     100.0ns]  CLK       0 -> 1
[time =     108.0ns]  OUT2      0 -> 1
Simulation stopped at 200.0ns.
sim>
```

```
WAVE>
```

Three versions are offered: the entry-level Workview 100, which is priced from $3,500 to $5,500; the digital-design Workview 300, priced from $6,500 to $8,500; and the analog-design Workview 500, priced from $5,500 to $8,500.

Viewlogic Systems Inc., 33 Boston Post Rd. W., Marlboro, Mass. 01752. Phone (617) 480-0881 [Circle 350]

CAD tool automates the making of pc-board test fixtures

The Pen-Entry Test Head Programmer, a computer-aided-design system for automating the manufacture of pc-board test fixtures for bare board and in-circuit automatic test equipment, claims to save up to 70% on labor and time over manual systems.

Generating numerical control tapes to drill and wire the test head on automatic machinery, the programmer also plots a node map of the test head and automatically labels the interface-block pin numbers. The node map permits nodes to be located for both fixture wiring and post-testing rework quickly, the company says.

The system consists of a 15-in. CRT, a control center with keyboard, a CPU with 136-K bytes of memory, an 8-in. floppy-disk drive, a 1,500 characters/s paper-tape reader, a high-speed tape punch, and an 11-by-17-in. flatbed plotter. Prices start at $39,500. Delivery takes four to six weeks.

Wire Graphics Inc., 215 B Central Ave., Farmingdale, N.Y. 11735.
Phone (516) 293-1525 [Circle 351]

Indexer and power amplifier come packaged together

In a departure from separate drives and indexers, microstepping-indexer and power-amplifier functions have been combined in a single package that measures 2 by 4 by 6.5 in. Suitable for original-equipment-manufacturer applications, the compact DH-series indexer/drive uses pulse-width-modulated outputs that switch at an inaudible 20 kHz and microsteps the manufacturer's hybrid motors to a resolution of 5,000 steps/revolution.

Power MOS FET technology allows the system to drive motors to torques of 400 oz-in. Internal circuitry automatically boosts current by 33% during acceleration and deceleration, ensuring maximum motor performance under all operating conditions.

The indexer/drive combo has an RS-232-C interface so that any computer or ASCII terminal can control the motor. Commands to the indexer section of the unit handle tasks such as setting acceleration, velocity, and distance parameters; moving to an absolute position; stopping; or searching for an external home-position reference, among others.

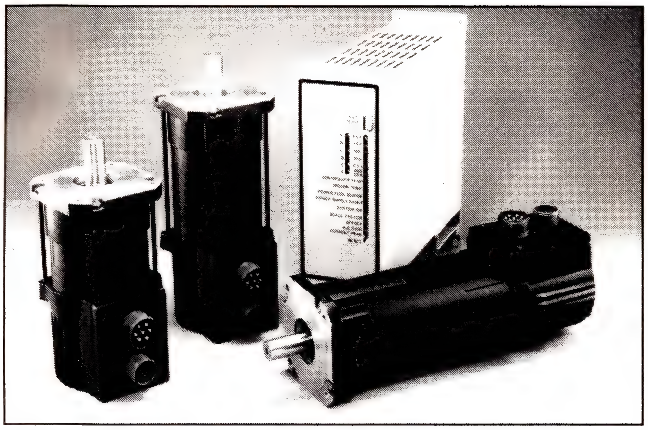
The six models in the DH series range in price from $1,157 to $1,390, in lots of one to nine pieces. A power supply, model DH-1, goes for $375. Delivery begins at the end of the month.

Compumotor Corp., 1179 N. McDowell Blvd., Petaluma, Calif. 94952.
Phone (800) 358-9068; or in Calif., (707) 778-1244 [Circle 366]

Brushless motors with 6.4 hp come with matched amplifiers

A line of brushless motors and their matched amplifiers from PMI Motors Inc. offer high acceleration and produce full torque at high speed. The trapezoidal design (torque to displacement) of motor windings results in low torque ripple at all speeds.

Called Relpak, the brushless servo motors are compact and rugged, and, thanks to their winding design, they do not run hot. Available in three sizes to 6.4 hp and rated speed of up to 5,000 rpm, the motors have an integral tachometer. A fail-safe brake and optical encoder are available as options.



The matching amplifiers are fully regenerative pulse-width-modulated four-quadrant units. They are fault protected and feature a front-panel diagnostic display.

PMI Motors Inc., 5 Aerial Way, Syosset, N.Y. 11791.
Phone (516) 938-8000 [Circle 360]

Linear actuator controls motion better than solenoids

Although it resembles a typical solenoid, a new type of linear actuator provides the precise movements that were previously unattainable with conventional solenoids. Called a controlled field actuator (CFA), the device is suitable for applications in automobiles, robotics, office and industrial equipment, valves, and consumer electronics and appliances.

The CFA overcomes the inherent limitations of solenoids, such as uncontrolled force, variations resulting from voltage changes, lack of positioning capabilities, and noisy operation. The CFA maintains any desired constant force level not exceeding its thermal or voltage limits, regardless of plunger position.

Force can be set to any desired level, so the efficiency of the CFA is much greater than that of an equivalent-size solenoid. Unlike solenoids, the CFA's power dissipation decreases as the plunger pulls in, the manufacturer says. The model 10-G100C17 has a peak current draw 0.4 A at 25°C. CFA application development kits sell for $150 each.

Synektron Corp., 12000 S.W. Garden Pl., Portland, Ore. 97223.
Phone (503) 684-3090 [Circle 359]

Positioning system moves about on a 360° track

A multislide positioning system capable of high speed and long travel operates in a 360° work envelope. The Anorail closed-loop positioning system features the manufacturer's patented linear dc servo motors for driving up to six short slides that ride on a linear U-shaped channel base.

Travel distances from 1 in. to 10 ft are possible, with speeds up to 60 in./s and stopping accuracies of ±0.002-in. per foot of movement. The Anorail is suitable for such applications as fast and accurate parts transfer, insertion, and inspection.

To support several work stations, the Anorails use up to six slides in a continuous-loop positioning system, featuring a 90° or 180° curved channel butted to the ends of the linear sections. Anorail slides can be independently positioned anywhere along the straight sections.

A minimally configured system starts at $3,000, with delivery taking six weeks after ordering.

Anorad Corp., 110 Oser Ave., Hauppauge, N.Y. 11788.
Phone (516) 231-1995 [Circle 361]

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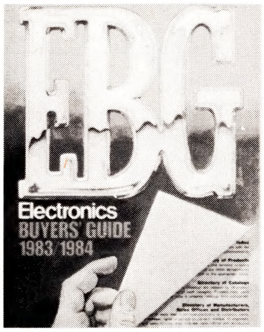

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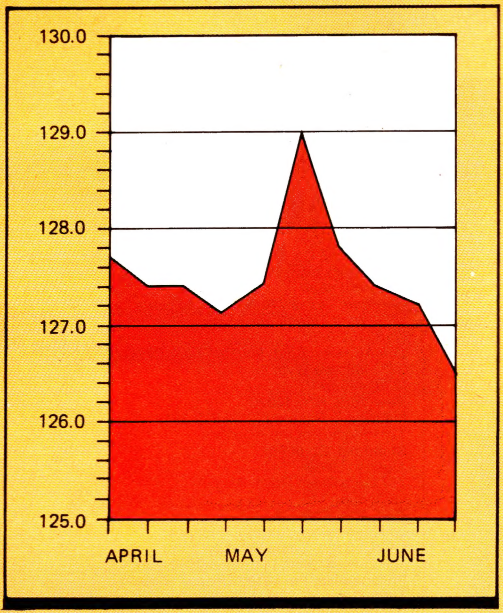
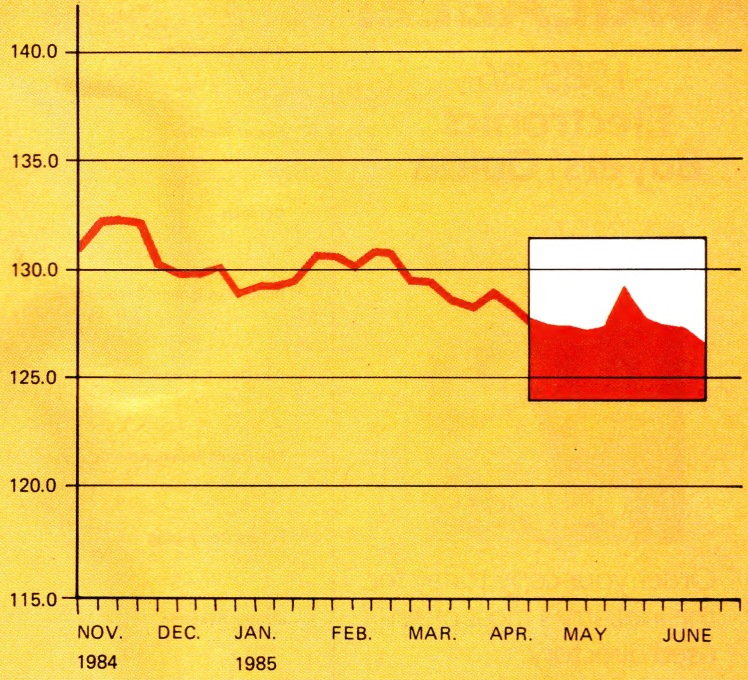
ELECTRONICS INDEX





THIS WEEK = 126.5
LAST WEEK = 127.2
YEAR AGO = 126.5
1982 = 100.0

The *Electronics* Index, a seasonally adjusted measure of the U.S. electronics industry's health, is a weighted average of various indicators. Different indicators will appear from week to week.

U.S. GENERAL ECONOMIC INDICATORS

	May 1984	April 1985	May 1985
Average prime rate (%)	10.31	10.50	12.39
Retail sales ($ billions)	113.678	114.584	107.941
Unemployment rate (%)	7.2	7.2	7.4

U.S. ELECTRONICS PRODUCTION INDEX

	April 1984	March 1985	April 1985
Office and data-processing equipment	353.8	364.5	308.2
Communications equipment	232.0	230.8	203.7
Radio and TV equipment	108.0	118.2	114.8
Electronic and electrical instruments	179.2	180.2	171.0
Components	426.4	441.8	447.7

A massive drop in the reported production of electronics equipment pushed the *Electronics* Index down 0.6% in the latest week. The cataclysmic 3.1% tumble in April production brought the Index to its lowest point in nearly a year. What's more, production of electronics equipment in April stood at its lowest level since October, according to the latest government statistics.

Though no sector of the electronics industry made any significant production gains in the month—in fact, the communications-equipment sector was the only area with any gains in production at all—none suffered as badly as companies producing radio and TV equipment. Production of radio and TV equipment plunged almost 9%, bringing industry output to about 6% less than it was a year ago. Despite this, April's decline was not nearly as severe as January's 22% drop in radio and TV production.

Another big loser was the computer industry, which saw output slip 3.2% in April. With the recent spate of plant closings and layoffs within the computer industry, production levels in future government reports will probably go lower still. As might be expected, with production of equipment down, semiconductor production in April fell to 95% of its level of a year ago.

The high rate of the dollar overseas continues to be a thorn in the electronics industry's side, stifling exports abroad and helping foreign manufacturers further penetrate the domestic market. Interest rates in the U.S. continue to fall, but this isn't helping push the dollar down.

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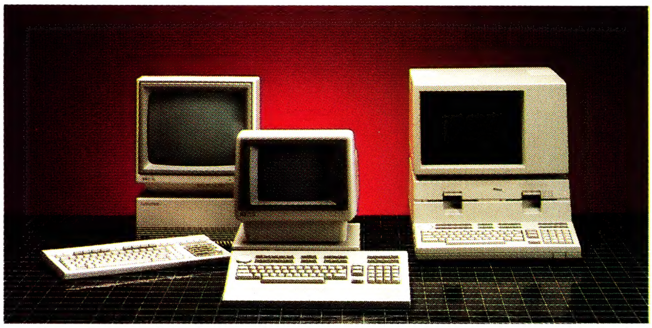
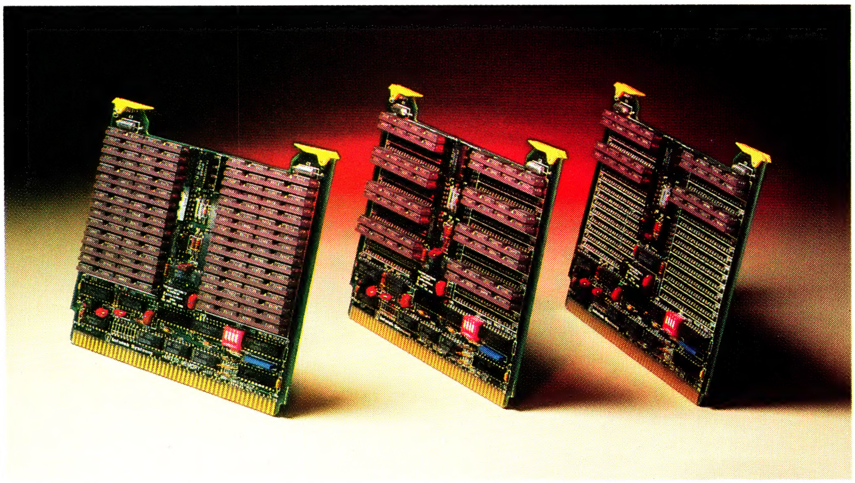
Give your Hewlett-Packard Series 200 computers the Infotek Advantage...

...up to four megabytes on a single board.



HP 200 Series
Computers 217, 216, 236.



Pictured left to right: AM 244 (4MB), AM 242 (2MB), AM 241 (1MB)

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Infotek has been supplying HP enhancement products to Fortune 1000 companies for almost ten years.

SINGLE BOARD SOLUTIONS:

Your HP 9816 computer can now be configured with 1MB, 2MB or 4MB of memory in a single slot.

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Just install the board in any I/O slot.

COMPLETE COMPATIBILITY:

All Infotek memory boards are 100% compatible with HP memory boards.

UNIQUE FLEXIBILITY:

Upgradeable memory — another Infotek innovation. Buy the memory you need today and upgrade to meet future requirements.

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Infotek boards are tested for seven full days in HP 200 Series computers. Our record of better than 99% reliability speaks for itself.

WARRANTY — TWO YEARS:

Infotek hardware products are backed by the best warranty available. Two solid years.

AFFORDABLE PRICE:

All Infotek products are priced to save you money. And we offer the best discounts to volume and OEM customers on top of our affordable prices.

MEMORIES

AM 200 — 1 MB	$1,650
AM 241 — 1 MB (Upgradeable)	2,600
AM 242 — 2 MB (Upgradeable)	4,000
AM 244 — 4 MB Memory	6,800

MEMORY UPGRADES

UK 212 — 1 MB to 2 MB	$1,800
UK 214 — 1MB to 4 MB	4,600
UK 224 — 2 MB to 4 MB	3,200

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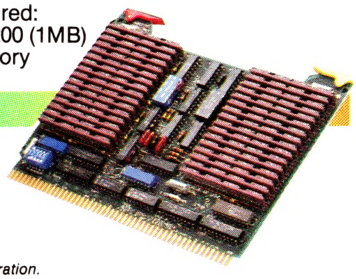
All Infotek products are available from stock. We know how important your schedules are.

So before you order your next memory boards, call Infotek and compare. OEM, government, educational and quantity discounts available.

Pictured:
AM 200 (1MB)
Memory



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Circle 901 on reader service card

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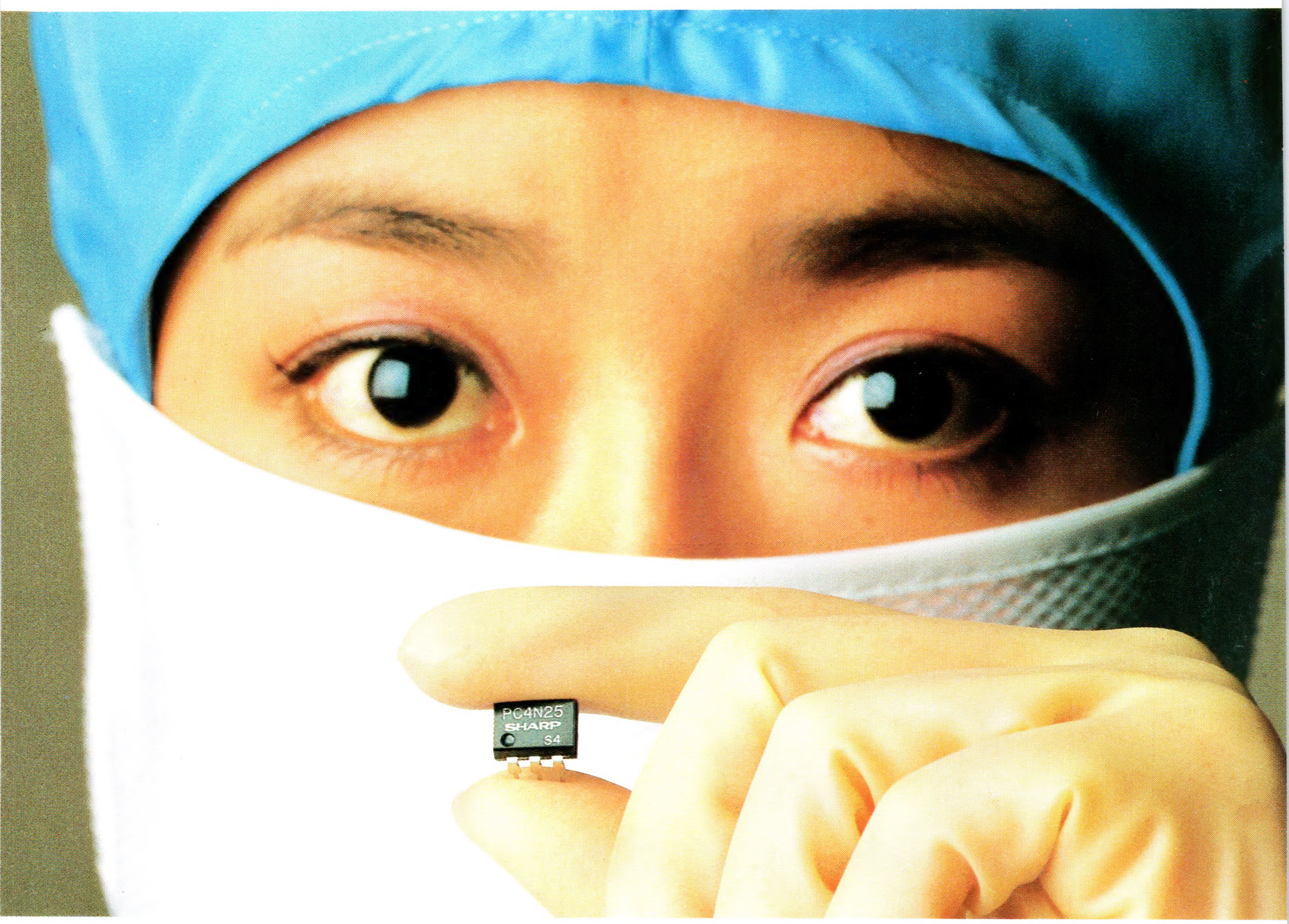

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On the outside, all 4N series photocouplers basically look alike. The difference is inside. With Sharp PC4N photocouplers, that difference is reliability. Every Sharp PC4N incorporates Sharp's sophisticated electronics technology. And each phase of the manufacturing process is carefully monitored under Sharp's strict standards of quality control. This means that Sharp PC4N photocouplers will perform up to specification the first time—every time— you use them.

If reliable performance is important to you, take a look at Sharp's line of PC4N photocouplers. They're high-performance electronic devices with a difference—Sharp reliability. You can count on it.

PC4N-Series

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	Model No.	Absolute Maximum Ratings		Electrical Characteristics							
		Collector-Emitter Voltage	Isolation Voltage	Current Transfer Ratio			Response Time				Collector D Curren
		V_{CEO} (V)	V_{iso} (V_{rms})	CTR (%) MIN.	I_F (mA)	V_{CE} (V)	t_r (μs) TYP.	I_C (mA)	R_L (Ω)	V_{CE} (V)	I_{CEO} (nA) MAX.
Single Phototransistor	PC4N25	30	2,500	20	10	10	3	2	100	10	50
	PC4N26		1,500		10	10					
	PC4N27		1,500	10	10	10					
	PC4N28		500		10	10					100
	PC4N35		3,550	100	10	10	3 (t_{on})	2	100	10	50
	PC4N36		2,500		10	10					
	PC4N37		1,500		10	10					
Darlington Phototransistor	PC4N29	30	2,500	100	10	10	MAX. 5 (t_{on})	50	[I_F] *200 (mA)	[V_{CC}] 10 (V)	100
	PC4N30		1,500		10	10					
	PC4N32		2,500	500	10	10					
	PC4N33		1,500		10	10					

*$t_w \approx$ 1.0ms

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Circle 902 on reader service card